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Breeding Biology of the Chimney Swift

Chaetura pelagica (Linnaeus)

By

RICHARD B. FISCHER
Museum Expert
New York State Museum and Science Service

NEW YORK STATE MUSEUM
AND SCIENCE SERVICE

BULLETIN NUMBER 368

The University of the State of New York
The State Education Department

Albany, N. Y. April 1958

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THE BREEDING BIOLOGY OF THE CHIMNEY SWIFT

Chaetura pelagica (Linnaeus)

By

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PREFATORY REMARKS AND ACKNOWLEDGMENTS

This account is written from information gathered during many years of field observations. A portion of the study was carried out under the auspices of the New York State Museum and Science Service. The original data formed the basis for a doctoral dissertation which was submitted to the Graduate School of Cornell University on September 15, 1953. Additional literature has appeared in the intervening years; where pertinent, I have incorporated the findings in the present report.

A large measure of credit is due my mother, who provided living quarters for me in the study area during 14 summers of research.

A special word of thanks goes to the farmers and landowners at Beaver Kill who gave me ready access to their buildings: To the Woelfles, Ackerlys, Virtues, Osborns and Banks; to the wonderful folk at the Beaver Kill Trout Club—President William Jensen; the members, who were always interested in my studying their swifts, and the housekeepers, Mrs. Emery, Mrs. Hanley, Mrs. Marshall, Mrs. Conklin and the Pierpoints, whose enthusiastic assistance greatly expedited the work.

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*Temporary Museum Expert, New York State Museum and Science Service.

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All times given are eastern daylight saving time (an hour earlier than eastern standard time).

All photographs and graphs were made by the author. The cover drawing is by William C. Dilger.

INTRODUCTION

Historical

The Apodidae or Swift family is a cosmopolitan one lacking representatives only in the extreme north and south where suitable nesting places are absent. It is most abundant in the tropics. Until recently, ornithologists placed them in 16 genera and 76 species (cf. Peters, 1940, and Mayr and Amadon, 1951). Lack (1956: 1-32) proposes a reduction to 9 genera and less than 76 species. Most species have been split into geographical races; thus far, the American chimney swift, *Chaetura pelagica,* is considered to be generically monotypic and with no subspecies.

Although swifts and swallows appear, to untrained eyes, to be closely related, there are major differences separating them. All swifts possess 10 tail feathers; whereas, the swallows invariably have 12. Ridgway (1911: 682) gives as other characteristics the aegithognathous palate, absence of caecae, nonscutellate tarsi, the relatively small hallux which may be directed inward or forward, 10 greatly elongated primaries with the tenth or ninth the shortest, the relatively very short secondaries 8 to 11 in number, and the usually more or less forked or emarginate tail with the shafts of the rectrices (in the subfamily Chaeturinae) often very rigid and extruded. And in building their nests, swifts glue the material together with their saliva—perhaps a unique trait among birds.

As a group the swifts are not well understood either as to their taxonomy or as to their behavior. Only during the past 20-odd years has much work been done on several of the Old World species, the major papers appearing in the 1940's and 1950's.

In 1941, Moreau published his study of the breeding biology of the palm swift, *Cypselus parvus,* followed in 1942 by a similar investigation of the white-rumped swift, *Apus caffer streubelii;* both were made at Amani in Africa. In these he compared aspects such as nest relief, feeding the young and development of the nestlings.

Arn, in Switzerland, studied the Alpine swift, *Apus melba,* and published his results in 1945. He had investigated egg-laying, incubation, hatching success, the nestling period, nestling mortality and the weights of young and adults.

Weitnauer, also in Switzerland, brought out an important paper on the common swift, *Apus a. apus,* in 1947. Working with banded birds, this researcher did an extensive piece of work on phases of breeding biology that included clutch-sizes of the same female, egg

weights, incubation, hatching success, nestling survival, length of the nestling period, weight gains and losses of the growing young, feeding frequency, and peak weights of the nestlings.

In the same year, Lack and Arn published the results of their research on the significance of clutch-size in the Alpine swift. Their thesis was "that clutch-size in the Alpine swift is ultimately determined by natural selection, that 3 is the commonest clutch-size because 3 is the commonest family size which results in the maximum number of young being raised per pair, and that the main factor limiting family size is the amount of food which the parents can collect for the young."

Quite a different investigation was that of Koskimies in Finland. He prepared a long paper in 1950 on the life of the common swift in relation to the weather. Several very interesting starvation experiments are detailed in the report, and there is a particularly long bibliography.

Then in 1951 and 1952 the Lacks placed two more major contributions in the literature. Their long, scholarly, thoroughly documented papers—which helped to guide the present endeavor—dealt with most of the aspects of common swift breeding biology previously treated by Arn, Koskimies, Weitnauer and others. Through an excellent use of the literature they drew numerous parallels and contrasts with various species of swifts besides *Apus apus*. Subsequently (1956) Dr. Lack brought together many scattered references for his helpful paper on the taxonomy and comparative nesting habits of swifts.

Our chimney swift is one of the widely distributed birds in North America. Dr. E. M. Reilly, Jr., now preparing material for the coming fourth edition of *A. O. U. Check-List of North American Birds*, gives its breeding range as

> from northeastern Saskatchewan (Indian Head, probably), southern Manitoba, central Alberta, southern Ontario, and southern Quebec, south over the eastern United States to southeastern Texas (Houston), Louisiana, Alabama, Mississippi and central Florida.

While this species may be found wherever there are buildings—including the largest cities—this swift is most often encountered in rural areas. There this mysterious, unobtrusive bird finds unused chimneys, barns, silos and sundry outbuildings wherein it constructs a peculiar nest of sticks and rears its young in seclusion and near darkness. Formerly this species nested in hollow trees, but since the coming of the white man to North America it has taken

to occupying buildings to a great extent. We do not know to what degree it still nests in the ancestral type of site. The most recent reported nesting in a tree occurred in 1947 (Cameron, 1949: 114). However, if one ascends to the summit of a remote mountain (such as Slide Mountain in New York's Catskills) he will be struck by the presence of many more swifts than the manmade nest sites in the region could accommodate. He will conclude, as I have, that in large wilderness areas the chimney swift still nests in hollow trees or rocky places.

Dr. Maurice Brooks reported (personal communication) a most unusual nest site in the Blue Ridge Mountains of Virginia. In the region around Highland County a knifelike sandstone ridge runs along the mountain, reaching to 1,500 feet elevation in places. While afield near the village of Blue Grass in August 1936, he found four unoccupied chimney swift nests fastened to the rock under an overhanging ledge.

Most amateur bird watchers and professional ornithologists are acquainted with this swift, but few have undertaken serious studies of its breeding biology.

In the 1890's and early 1900's, Otto Widmann devoted considerable time to the species. His papers contain much good material on the saliva, nest-building, feeding and growth of the young.

Miss Althea R. Sherman began studying the swift at about the time that Widmann ceased. She published only one brief paper, but her posthumous book *Birds of an Iowa Dooryard* contains many useful excerpts from her extensive notes on nest-building, egg-laying, incubation, feeding, development of the young, reactions of the nestlings to their parents and to her, when the young leave the nest site, and the reuse of nests.

Contemporary, large-scale research on the breeding biology of the chimney swift is being done by Professor Ralph W. Dexter at Kent State University in Ohio. Dr. Dexter has an enviable situation in that his birds nest in air shafts atop the college buildings. Begun in 1944, his banding total now exceeds 500. Professor Dexter has obtained many returns and has devoted most of his reports to remating, change of mates and reuse (or change) of previous nest sites. Dr. Dexter's numerous papers are a valuable addition to the literature.

During the late 1930's and early 1940's a coterie of banders, including John B. Calhoun, Ben B. Coffey, J. C. Dickinson, Raymond Fleetwood, Wyman R. Green, Harold B. Hitchcock, Mrs. Amelia R. Laskey, George S. Lowery and Harold S. Peters, did

magnificent work with migrating birds. In 1939 they marked 71,623 swifts, with Peters taking more than 6,000 out of a chimney in Georgia in a single day. Many significant papers on chimney swift migration have emerged from their work.

Having marked fewer birds during my entire study than any one of the southern banders would tag in a day, I am not qualified to discuss the chimney swift's migration; furthermore, that was not an aim of these studies. Their papers do contain much life history material. Some (see bibliography at end of this bulletin) which I found especially helpful were: J. B. Calhoun (1938), B. B. Coffey (1936), J. B. Calhoun and J. C. Dickinson (1942), W. R. Green (1940), H. B. Hitchcock (1945), G. H. Lowery (1943) and H. S. Peters (1937).

For a time there was a lull in the group's activities, but present indications point to renewed operations. Dr. Harold Peters writes me that in the fall of 1952 Mr. Gordon L. Hight of Atlanta, Georgia, established a new record by capturing nearly 7,000 swifts in a chimney in one day in Georgia.

At this writing (June 1956) the number of chimney swifts banded since 1924 stands at 550,142. *Not less than 95 percent of them were banded as nonbreeding birds.* The large-scale banders have obtained very many recoveries and returns and, were it not for them, we might still not know that the species passes the winter in the rain forest of the Amazon. It was not until 1943 (Lincoln, 1944: 607-608) that we learned that breeding swifts from a wide area in North America went to the region between the Putumayo and Napo Rivers, tributaries of the Amazon, in northern Peru. Both Lincoln and Ganier (1944: 39-41) had few details of the recovery at their disposal, but Brackbill (1950: 17-21), who interviewed the man who actually turned in the 13 history-making bands to the American Embassy in Peru, added considerable amplification. Since then only one additional banded chimney swift has been retaken in South America. It was one of a flock of about 1,020 which Ben B. Coffey banded near Memphis, Tennessee, on September 25, 1954. On November 4 it was collected at Trujillo, Peru, about 540 miles southwest of the 1943 recovery area (Coffey, 1956: 84).

Nevertheless, those who deal year after year with nesting chimney swifts secure a much higher *percentage* of returns to former nesting places. Green himself said (1940: 53) that "banders should now give their attention to the banding of nesting pairs, and their young, before they leave the nests."

The present studies

The investigations on which this account is based were conceived in 1939, when I discovered how to catch chimney swifts at their nest sites. Realizing that little was known of the nest life, I kept notes on the birds I worked with and as summer followed summer I amassed a considerable amount of information. The research took on new meaning and direction when it became my doctoral problem.

Techniques employed

Capturing adult birds

The classical method of capturing chimney swifts involves setting a trap atop a chimney after the birds have entered to roost. As day approaches, the swifts leave the chimney and are guided into a gathering cage attached to the trap. Photographs and descriptions of this method have appeared in the papers by Bowman (1953), Calhoun and Dickinson (1942), Dexter (1950) and Green (1940). Although this is an admirable procedure when used on flocks of swifts, it leaves much to be desired when one is studying breeding individuals.

During the present investigations I developed a technique (Fischer, 1951) that has worked very well. On either side and just under the lip of a tall coffee or number 2 fruit juice can I punch two holes. Next I fasten the ends of a four-foot length of soft iron wire to each hole; this gives a 'handle' two feet long. To the top of the handle I tie one end of a ball of kite cord.

When the swifts have gone to roost, I climb quietly to the chimney and quickly cover it with a trout landing net, insect net or, preferably, a fish seine. It is especially important to cover the chimney in the early part of the nesting cycle, for at that time the swifts will not hesitate to leave it after dark. Then I shine a headlight down the chimney; this usually causes the birds to flutter downward. Paying out some cord in advance, I lower the can rapidly to a point below the lowest bird, which solves the biggest problem in the operation: to prevent the frightened birds from dropping down into the fireplace or whatever the chimney connects with. At this point it is important not to allow the can to bang against the sides of the chimney, since noise might send the swifts fluttering suddenly upward and some might escape.

To capture any desired individual, I bring the can up to it from below so that it does not quite touch the bird's tail, where-

upon a quick upward jerk scoops the swift into the can. Once in, a bird is unable to escape, because it cannot gain a foothold on the slippery sides nor can it raise itself with its wings. The swifts are hoisted up one by one, placed in a gathering cage on my hip and finally taken indoors for examination and banding. With this technique one can capture all the birds present in a few minutes. Swifts roosting in a deep chimney or air shaft present a slightly different problem, for after their initial reaction to a disturbance, they tend to drop down deeply. When this occurs I lower the can to the very bottom and bang it against the sides. This, together with attempts to catch the lowest birds, drives them upward. Here is where a seine across the top of the chimney is advantageous. Since I carry out the raising and lowering of the can with my hands under the netting, if a swift comes flying up I simply grab it.

Occasionally I keep birds overnight, more often I replace them. I have found that if I place a swift as far down in the chimney as I can reach, the bird will soon drop deeper of its own accord.

This technique is superior to the trap method since it enables one to "work" all the chimneys in an area in one night without building separate traps for each one. When hundreds of swifts are present in a chimney, a trap would be more efficient.

It is not difficult to capture swifts nesting inside a building, though it is frequently time consuming. Steps must be taken to prevent their escape, usually via a window. The easiest way to accomplish this is to fasten one edge of a feed bag (or any piece of material) to the top of the window. Next I roll this up and tack it lightly above the window, by the middle, with a staple or roofing nail to which I tie a long piece of twine. When I return after dark to catch the swifts, I tug sharply at the twine thereby loosening the staple; the bag unrolls and covers the window. I secure the birds with an insect net and electric headlight.

Marking swifts

Adult chimney swifts were permanently marked with standard Fish and Wildlife Service bands. In a study of this kind it was essential to be able to recognize the males and females at a glance without having to capture them. During 1950 I marked the birds by gluing variously colored and differently patterned feathers to their backs, using Duco household cement. This identified the birds at the nests, but proved valueless outdoors. Therefore, in 1951 and 1952 I experimented with Testor's model airplane dope.

At first I painted all parts of the tips of the outer primaries. When the dope had dried, however, these feathers did not resume their normal, shingle-like arrangement, and the result seemed to decrease the birds' flying efficiency. Only two birds were painted thus.

When next I marked a wing, I held the bird so that its wing was pressed against a flat surface, the feathers maintaining their normal overlap. Both sides of the wing tip were painted, care being taken to prevent dope from getting into contact with those portions of the feathers that overlapped. This yielded a strikingly marked wing which in no way impaired flight, and birds so marked could be identified at a distance of half a mile.

White, light blue and yellow showed up best on these dark birds, and the wing was the best area to mark. I tried red on the throat of one swift, but even when the bird passed over low the color was difficult to detect.

When the young swifts were too small to band, I marked them with a dab of airplane dope placed on the head, back, rump or abdomen. This was probably not the best method, for the dope had to be replaced almost daily. Colored thread tied to the tarsi would probably be better. Regular bands were affixed when the nestlings were nine days old, and in a special order. For each nest I chose a group of bands whose last numbers were 1, 2, 3, 4 and 5. The lowest number I attached to the youngest bird, the next higher band to the next oldest and so on. This greatly facilitated record keeping.

Weighing swifts

To obtain data on the weights of young and old birds I used a standard platform balance such as one might find in any high school chemistry or physics laboratory. The instrument was accurate to one-tenth of a gram, which was sufficient for these studies.

Adult swifts and young older than 10 days were weighed in a cloth sack; subtracting the weight of sack (which changed from day to day because of varying relative humidity and the absorption of feces) from the total weight gave the weight of a bird. Very young swifts could be weighed directly on the balance.

Obtaining temperatures of swifts

Before commencing this phase of the studies I did considerable reading on the subject and decided that an extremely sensitive nonself-registering thermometer graduated to tenths of a degree

would be the best instrument to employ. Unable to obtain such a device, I resorted to a physician's clinical thermometer which, I feel, yielded data within the limits of accuracy afforded by field conditions. I took a bird's temperature merely by inserting the thermometer into its mouth and pushing it gently downward until the bulb entered the proventriculus. In two minutes the mercury column would cease to rise.

Photography

I did most of the photographic work with a 3¼ by 4¼ inch Speed Graphic using Kodak Super XX film and, inside buildings, midget flash bulbs. To obtain pictures of nest life I set the camera on a tripod (or hung it from the roof timbers by wires) and tripped the shutter from my hiding place by remote control.

As a result of my experiences I should set down here—as a word of caution to those who read this in search of guidance—three rules that will help to attain good photographs.

A. Take some pictures and process the negatives with the equipment you plan to use *before* taking to the field.

B. At intervals during the research, develop some of the films to be sure you are getting satisfactory results. Do not rely on a friend but do the work yourself or take it to a regular photo-finisher!

C. Take many more photographs than you think you need, for when you examine the negatives critically you will discover that relatively few are really good.

Note-taking

In the closing years of these studies I evolved a technique of recording field observations which has much to commend it. I sat in the hiding place with a wristwatch hung at eye level and a clipboard provided with blank and fine-lined looseleaf paper on my lap. Whenever something occurred, I noted the time—simply by shifting my gaze—and recorded the action when it was completed. I numbered each page consecutively and wrote only on the front side; not only did this increase legibility, but it left the other side free for later amplification of notes previously written in haste. A fountain pen was vastly superior to pencil in that writing was faster, less tiring, more legible and much more permanent.

Certain types of data, such as weights and temperatures, that were obtained each day went on special sheets in approximately

tabular form. Thus they were not buried in the body of field notes, and with the information already assembled the construction of tables and graphs was facilitated. While sitting in the blind, I also jotted down on a separate page the research ideas that came to me.

THE STUDY AREA

Geographic location

Except for occasional observations in other parts of New York State and the East, these studies in the breeding biology of the chimney swift were made in the very small hamlet of Beaver Kill in the Town of Rockland, Sullivan County, New York. The study area is on the northwest edge of the Catskill resort region to which thousands of New York City dwellers come every summer.

Natural characteristics

With an average elevation above sea level of 1,600 feet, Beaver Kill lies within both the Transition and Canadian life zones. One hundred years ago hemlock was a dominant tree there; now, half a century after the last tannery stopped utilizing hemlock bark, it is increasing again. Good, albeit second-growth, stands of birch, beech and maple hint of the lumbering that went on when sawmills and "wood acid" factories were active in the area. Vigorous —and precarious—agriculture was practiced on the poor, hilly soil at one time, but as the old people passed away and their offspring made for the cities, farms were abandoned and the forest crowded in anew.

Many of the farms were purchased by "city" people for use as summer places. This worked to the swifts' advantage, since the new owners usually kept the farm buildings in good repair and thus preserved many nesting places.

Nesting sites

The chimney swift, widely distributed in the study area, is one of the few resident species which can be seen on any day even though it is outnumbered by other birds. When any particular individual comes to rest, however, that bird usually disappears into a building or chimney. I have found no record in the literature of a swift's perching in a tree like a passerine, but several years ago Mrs. William Taylor, afield in Michigan with a number

of other persons, saw an individual alight crosswise on a branch and remain there for some moments.

At Beaver Kill the swift occupies buildings more often than chimneys. This is due to the fact that cool nights and mornings prevail until late June, so the home owners generally light a fire each morning, thereby discouraging the birds. In addition, summer vacationers drive the swifts away with occasional fires in their fireplaces.

Seven different tracts of land (farms) were occupied by chimney swifts during these researches. These tracts were as follows:

Ackerly Farm. This tract consisted of two dwellings, an icehouse and a barn with a 30-foot interior silo, which was removed after the 1950 breeding season. The silo was constructed of vertical, tongue-and-groove boards held together with iron rings around the outside. Swifts began using the silo at least as early as 1936 when I photographed young. I did not examine the site in 1937 or 1938, but from 1939 through 1950 the silo was unoccupied only in the summers of 1943 and 1944.

The swifts entered and departed from the silo only via a window above it. They fastened their nests to the boards nearer the window, thus occupying the shadier half of the silo; one nest was but 26 inches from the top while the lowest was 10 feet down. Most of the nests were located within an area smaller than 10 feet by 10 feet.

In 1952, swifts nested in a corner of the barn above the haymow. Their nest is pictured in figures 1 and 7. I banded them in 1952; they returned in 1953 and reared a brood in their former nest.

Beaver Kill Trout Club. Its buildings are two dwellings, two icehouses and two barns. One of the barns is large for that region and is still used to store hay. The other is used for parking automobiles downstairs and for storage upstairs. Swifts have nested in both barns as well as in a perennially unused chimney in one of the houses.

To judge from the vast accumulation of droppings below the 1939 nest—the first I found in the smaller barn—it must be a very old site. Until the summer of 1947 the nest was always located high up on a partition upstairs, toward the rear (east) of the building, where the light was the least. From 1948 to 1952 the nest has been attached just below the west peak of the roof. For many years the birds entered and departed through a missing pane

in the window toward the barn's northeast corner. With the passage of time several panes became broken in the northwest window (more than were missing from the other) and the swifts used it after 1950.

The larger barn, whose period of occupancy was short, is interesting because it was the only one I ever knew to be inhabited by two pairs of chimney swifts simultaneously. Although I first found swifts in it during 1941, it is quite possible their occupancy commenced earlier. In that year a pair built their nest on and just below the top of a vertical, 2 by 4 inch joist above the window in the south gable. The nest was used in 1942 and 1943, at which time a second pair built on the face of a large board above the east window. Both gable sites were tenanted in 1944 but they have been vacant ever since. The birds came and went via the windows below their respective nests.

My records of the chimney in one of the houses are scant, because it was not always feasible to climb up on the roof. While the data show that birds definitely nested (or tried to nest) in it during 1948, 1950, 1951, 1952 and 1953, the "extra" swifts present at the tract throughout many summers indicated a continuous occupancy. The chimneys in the other house have never been habitable.

Woelfle "Farm." There are two barns here which resemble those at the Trout Club both in size and use, a large farmhouse and a woodhouse.

Chimney swifts occupied the woodhouse in 1942 (and very likely earlier), but Woelfle screened the window that autumn and birds could no longer enter.

In the summer of 1944, Mr. Woelfle tacked a very large, textured couch cover to the rafters of the smaller barn in approximately the middle of the roof and allowed it to hang down, nearly reaching the floor. Swifts found their way into the building the following summer by way of a single missing pane in a window, and they built a nest high up on the couch cover! With the exception of 1947, swifts nested on the cover every summer through 1951. (A pair was present in 1947 but deserted because I handled them.)

Mr. Woelfle removed the couch cover in the fall of 1951, but he gave me permission to erect a substitute the following spring. I tacked a braided rug approximately 10 feet square in the same position. The pair that had occupied the site during the previous two summers returned and built a new nest on the rug.

Mrs. Huske's Place. For the past 20 or more years this Tract has been used exclusively as a summer home. Its buildings are a

large house, a large two-story garage and an icehouse. With the gasoline rationing of World War II, the Huskes did not come to Beaver Kill, so it is most likely that swifts then occupied the chimney of the house—the only place they could use. I banded a pair with young in this chimney in 1944. From 1945 through 1949 I was unable to inspect the chimney; with the possible exception of 1945, I doubt that swifts were able to occupy it because the Huskes were present each summer since. During 1950 through 1952 I was able to examine the chimney (at night) before the people arrived and a pair of birds was always found. Although they were subsequently driven out by smoke, these individuals have provided some interesting data.

Ragan Farm. A neglected barn, a small dwelling and a two-car garage comprised the structures on this tract. A pair of swifts nested at the north end of the haymow in the barn during 1944 and they might have been present the previous year. A vertical board measuring about 4 feet by 6 inches, missing from the south end of the mow, served as a passage. Swifts have not bred there since 1944, and when the entire south side of the barn fell down in November 1951, the site became unsuitable for the species.

Mr. Virtue's Place. On this tract are a large house, a one-story four-car garage and a small two-story building housing a gasoline diesel electric generator downstairs and serving for storage upstairs. I found a nest at the north end of the upper room in 1947, but droppings below the nest showed that birds first bred there in the preceding summer. The nest was above the 8¾- by 7-inch window—their means of entrance and departure—and just below the gable. Swifts were not present there after 1950.

Jewett Allen's Farm. While there were a large house and barn, two smaller barns, a saphouse and three chicken coops at this farm, only one pair of swifts ever bred there. The birds built a nest on the wall of one of the two silos in the big barn in 1948, returned in 1949 and then vanished. They came and went through a window atop the silo.

ADOPTION OF MANMADE STRUCTURES

The chimney swift's shift from tree sites to manmade structures took place rather early in the settlement of this continent, yet there are (understandably) few references on the subject before the 19th century. Palmer (1949: 327) cites Josselyn who wrote in

1672 that the bird—Josselyn called it the *Troculus*—was occupying chimneys in Maine. By the beginning of the 19th century, Wilson (1812: 48) knew the bird to occupy only chimneys in Pennsylvania, though he stated that it still built in hollow trees in the remote, western forested regions. Audubon, too, was aware of the change in the swift's habit, but he wrote (1840: 164) that in Lower Kentucky, Indiana and Illinois the species continued to use the branches and trunks of hollow trees.

Accounts of nests inside buildings appeared in the journals at least as early as the 1870's. Sears (1873: 751-752), in relating their nesting in his barn at Beverly, Massachusetts, in 1871 and thereafter, commented that it was "a remarkable variation in the habits of the chimney swift." Sears' account prompted a note by Merriam (1874: 367-368) who made a similar observation in Lewis County, New York, at about the same time.

At Mt. Carmel, Illinois, Ridgway (1874: 201) found a nest inside a plank kiln used to dry tobacco and another in a hollow sycamore tree (*Platanus occidentalis*). Sage (1881: 50) told of a nest in a deserted camp in Maine. Two years later Smith (1883: 504) related a similar instance.

Evermann (1889: 30) wrote:

> A pair fastened their nest in 1884 upon the inside of the door of an out-house at the Vandalia depot in Camden (Indiana). The birds entered the building through small holes made in the gables. This building was in daily use, but those who visited it were cautioned by the railroad agent to open the door with care so as not to jar the eggs from the nest. . . The nest was repaired and used again in 1885, and again in 1886. . .

Kennard (1895: 314), who found a nest in an old log barn, commented that such a location was new to him since he always thought the bird built in chimneys or hollow trees. Other instances of nests in deserted camps in Maine were recorded by Powers (1896: 7) and Moore (1902: 62) offered the opinion that in his locality (New Brunswick) the swift nested inside buildings more often than in chimneys. At about the same time, however, Daniel (1902: 17) related that chimney swifts were nesting inside hollow cypress trees (*Taxodium distichum*) in the Dismal Swamp of Virginia.

Bailey (1905: 130), taking advantage of the opportunities offered by a pair in a barn near Syracuse, New York, obtained the first good photographs of nest life.

In Missouri, Widmann (1907: 132) wrote that the species still observed its old custom in regions where there were water tupelos

(*Nyssa aquatica*). He prophesied that the habit would become less common "as did the use of hollow sycamores (*Platanus occidentalis*) a generation ago" (ibid.). Honywill (1909: 266), writing of a nest he discovered in 1907 inside a deserted hunting cabin in the lake region of Minnesota, thought that two or three pairs of swifts were nesting in a large hollow stump standing on the bank of a nearby stream, but he was unable to get to it to be certain. Barrows (1912: 381) quoted a correspondent as saying that in Kalkaska County, Michigan, the bird nested in hollow trees, and as late as 1914 Reed (1914: 269) wrote that "large hollow stumps are known where hundreds nest every year." From the 1920's onward, papers dealing with swifts in chimneys and inside buildings became more numerous while references to tree nests declined sharply. Cameron's (1947) observation of a nest in a pileated woodpecker (*Dryocopus pileatus*) cavity in Nova Scotia was the only recorded instance in more than 30 years.

The shift away from trees has involved manmade structures other than buildings. Morrell (1899) recorded a nest in a well in Maine. At Scotch Lake, New Brunswick, Moore (1902: 162) saw a nest in a blacksmith's shop only 15 feet from the forge, and he related that "a number of years ago a pair nested in the upper part of a house in which a family lived and near to a bed in which children slept every night."

Maxon (1903: 133) reported a second well site (during the summer of 1895) from New York, while Hyde (1924: 157) discovered a nest in an abandoned Illinois cistern. Lewis (1927: 265) later told of another nest in a well, this one from Virginia. In his *Florida Bird Life* Howell (1932: 301) cited two instances of swifts' nests in wells.

An unusual example of nest site selection was placed in the literature by Staebler (1939: 336) who chanced to find a nest in a wooden sprinkler used to ice logging roads in winter. The location was the Mississippi Forest Reserve, 70 miles northeast of Sault Sainte Marie, Ontario, Canada. As he described it, "the nest was in the darkest corner, fastened to the side, within 10 inches of the top. The sprinkler is little more than a water-tight box on four sled runners . . . about 15 feet long, 8 feet wide and 5 feet high, and with all but a small portion of one end of the top boarded over."

Two students of the swift actually erected artificial chimneys in order to study the bird at close range. Widmann (in Bendire, 1895: 178) built a wooden shaft on the flat top of his tower; he did not describe the use or architecture of this tower. The shaft

measured 18 inches square and 6 feet high. Ready for occupancy on April 18, 1891, it was investigated by a swift the following day, and swifts nested in it during 1891 and 1892. This was at Old Orchard, Missouri.

Whether she got the idea from Widmann or not we do not know, but Miss Sherman (1952: 40) erected a special wooden tower in her garden near National, Iowa. Nine feet square and 28 feet high, the tower contained an inner 'chimney' 2 feet square that extended 14 feet down from the top of the tower. Through carefully located windows and peep holes, Miss Sherman could observe the swifts at close range. Her observations, embracing the period from 1918 through 1936, occupy two notebooks which are now the property of the Iowa State Department of History and Archives. Professor Ralph W. Dexter and I plan to edit and publish these valuable investigations.

NEST LOCATION IN THE STUDY AREA

At Beaver Kill chimney swifts have occupied a variety of sites and they have located their nests variously within those sites. To disclose any idiosyncracies the birds might have had in choosing the specific spots for their nests, I made certain measurements and tabulated them thus:

TABLE 1

Chimney Swift Nest Site Data

TRACT	DISTANCE TO WINDOW ABOVE FLOOR	BELOW ROOF	BELOW HIGHEST POINT OF ROOF	DISTANCE FROM PEAK*	DISTANCE FROM BOTTOM
A	5′8″	25′7″	2′2″	3′	4′5″	27′9″
B	8′3″	12′2″	11″	1′	2″	13′2″
B′	5′1″	28′3″	10″	2′3″	1′10″	31′6″
B″	4′5″	23′	10″	10″	0	23′10″
C	14′	11′6″	8″	1′11″	2′2″	13′5″
C′		12′7″	6″		1′3″	13′5″
F	1′11″	6′11″	10″	15″	8″	7′9″
G	25′	6′11″	3′	5′6″	3′	22′6″

Key: A — Silo at Ackerly Farm
B — Small barn at Beaver Kill Trout Club
B′ — East gable in big barn at Beaver Kill Trout Club
B″ — South gable in big barn at Beaver Kill Trout Club
C — Couch cover at Woelfle Farm
F — Woodhouse at Virtue's Place
G — Silo at Jewett Allen's Farm
* — Horizontal distance from nest to point beneath peak of roof

The table on page 23 contains numerical data in support of the observations of the author and several others; namely, that this species tends to select a dark place to nest. Such a location in a building would be relatively far from the nearest window. In the present studies, this distance ranged from 1 foot 11 inches to 25 feet. Interesting is the fact that though the Tract F nest was closest to the window, that exit measured only 8.75 by 7 inches and was the smallest at any site. As a corollary, the silo nest at Tract G—where the exit was large and admitted more light than at any other site —was placed 25 feet down.

In line with its preference for darkness, the chimney swift also chooses a spot well above the floor; i. e., just below the roof. Examination of the table will show that in most instances the nests were within one foot of the roof. The two exceptions to this (the silo nests at Tracts A & G) are readily explained on the basis of large exits that admitted so much light: The birds placed their nests further from the windows and, therefore, nearer the floors.

The urge for darkness at times outweighs other considerations. For instance, Woelfle's barn has a corrugated iron roof, and during a sunny day the heat in the upper part of the building often became unbearable. After a swift had been on the eggs for half an hour, I could see that it was growing increasingly uneasy and occasionally it would fly out without being relieved by the mate. I took some thermometer readings and obtained the following figures in degrees F.:

DATE AND TIME	TEMP. AT NEST	TEMP. AT FLOOR, 11.5 FT. BELOW	TEMP. IN SHADE
6/18/51 — 10:50 a.m.	90	73	76
6/18/51 — 3:30 p.m.	83	77	75
6/20/51 — 3:52 p.m.	84	77	75
6/21/51 — 12 m.	86	75	77
6/21/51 — 1:35 p.m.	89	79	—
6/21/51 — 3:03 p.m.	90	80	—
6/26/51 — 2:27 p.m.	89	78	—

There was an advantage for me in that the roof radiated so much heat that it was safe for the adults to be off the eggs or young for protracted periods. To be sure, the roof cooled off rapidly at night, but that created no problem since I rarely disturbed the swifts during incubation.

The site at Tract F must have suited the birds very well, and evidently the dark situation upstairs offset the nightly noise of Mr. Virtue's Delco electric system downstairs! When the generator was running, a person could not hear another's voice.

Mud dauber wasps (*Chalybion cyaneum*) had nests within three feet of the swifts' nests at Tracts B and C, but no disturbance of

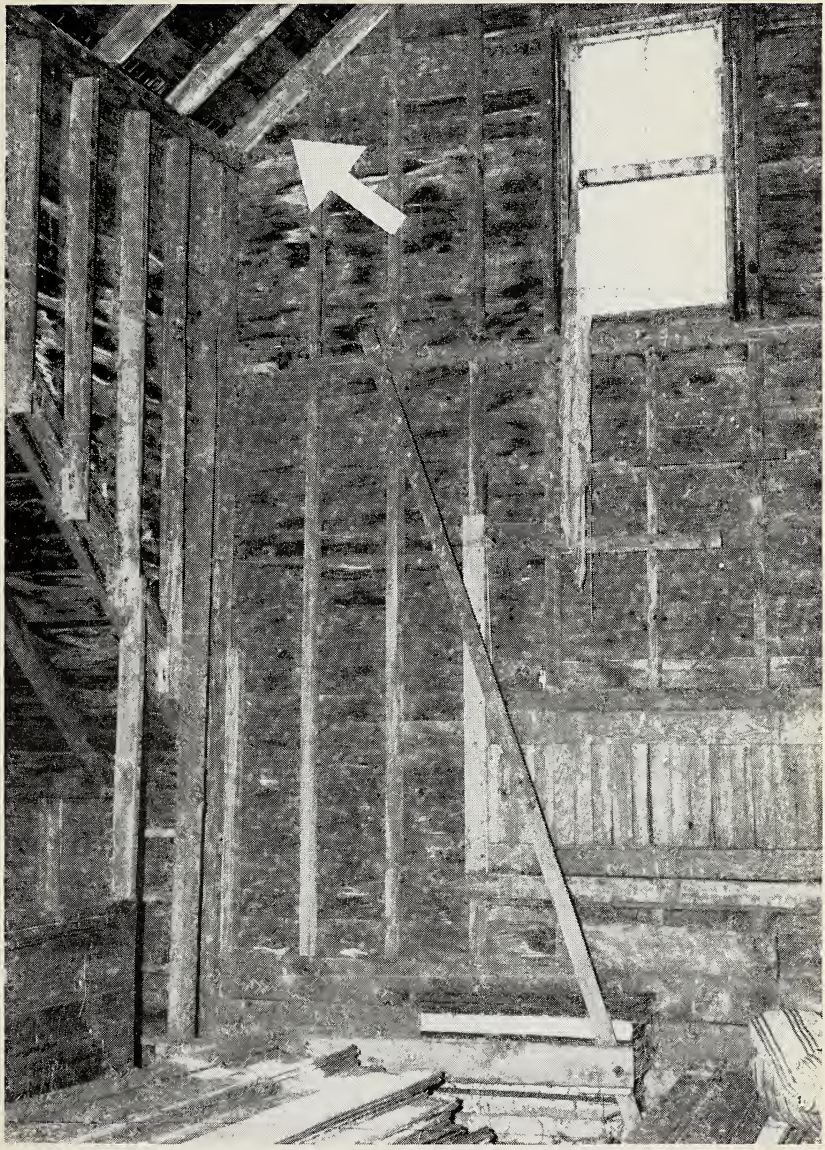


Figure 1. The 1953 haymow nest site at Tract A (arrow indicates nest). The nest was reused by the same pair in 1954. Photographed July 2, 1953.

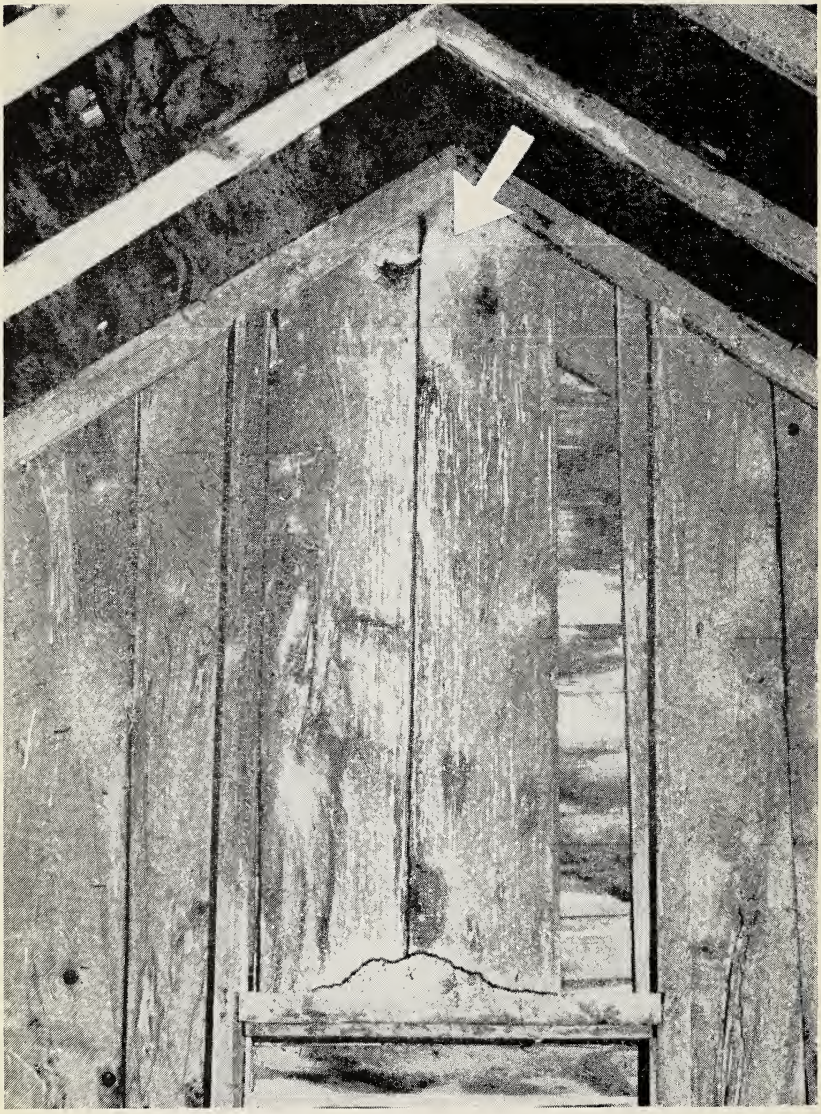


Figure 2. A much-used nest site on the east wall of the smaller Tract B barn. Note accumulated droppings (outlined in black). Arrow indicates the position of an earlier nest. Photographed August 28, 1946.

swifts from their presence was ever observed. Kennard (1895: 314) found a nest "within one foot of an enormous hornets' nest. The five young birds, which were nearly fledged, were clinging to the bark in the immediate vicinity and seemed to get on much better with the hornets than I did."

NEST SITE REQUIREMENTS

Chaetura pelagica

We have seen that darkness and shelter from the elements are prime requisites for this species. And though the bird gets its vernacular name from its new habit of nesting in chimneys, I shall show later (in the section on mortality) that these sites do not afford the degree of shelter offered by buildings. On the other hand, the increase and spread of the species to treeless areas is generally attributed to the abundant nest sites which chimneys provide.

That the complete absence of humans from the nest site, and even the immediate vicinity of the nest, is not essential is evident from several authors (cf. Evermann, 1889; Moore, 1902) as well as from my own observations. During the 1930's, Mr. Ackerly used to fill his silo with ensilage in late July; the Woelfle's often searched through their stored material in the barn, and Mr. Virtue operated his gasoline generator each night of the summer, yet none of these caused a desertion.

Some birds, e. g. the barred owl (*Strix varia*) and red-shouldered hawk (*Buteo lineatus*) seem to require nesting associates, and for a time in these studies I thought this might be true of the chimney swift when it occupied barns. In the summers when swifts nested in the Trout Club barn, about 15 pairs of barn swallows (*Hirundo rustica*) bred in it also. This was likewise true of the barn at Tract E. In each case, swifts ceased to use these barns during a period of decreasing swallow occupancy. However, consideration of the numerous instances of solitary nesting by the swift would rule out the barn swallow as a necessary associate.

A frequent requirement, quite apart from the physical aspects of the nest site, is that at least one of the previous year's adults return to the nesting place. When this happens, year after year, a site will be tenanted perenially, but when that situation does not occur, a tract sometimes goes unoccupied for a summer or more. A specific example will illustrate this.

Neither of the 1940 Tract A birds returned in 1941, but two new birds—numbers 936 and 937—nested there, one of which (936) was back in 1942. Upon the failure of either of the 1942 birds to come

back, the site went unused for the next two years. In 1945 two other swifts, 612 and 091, appeared, and 091 was back with a new mate in 1946. Since neither returned in 1947, the site was "open" and was used by two new swifts—604 and 605. Number 605 bred there in 1948 with a new mate (706) which, in turn, came back with a new partner in 1949. The following summer (1950) resembled 1947 in that both swifts (041 and 648) were new individuals. Their 1950 nesting was successful, but the silo was torn down that winter. Nevertheless, 648 (which turned out to be the female) was back in 1951, though there was no nesting in the barn that season or the next. To my surprise, swifts built on the south wall of the haymow in 1953, but as expected, they were new, unbanded birds.

A résumé of the tenancy at Tract C, whose complete record is known from the beginning of occupancy, will add further evidence. In 1945 the tenants were 608 and 611; 608 returned the next year with a new mate, 567. Number 567 was back in 1947 with a new partner, 569, but because I disturbed the swifts early in the breeding cycle, they did not nest. I was not surprised to find that the 1948 birds were both newcomers—numbers 648 and 561; they were mated again in 1949. Number 648 went over to the silo in Tract A in 1950, so 561 (a male) obtained a new companion, 036, that season. These two swifts bred in the barn in 1950, 1951 and 1952. When both failed to return in 1953, the site went unoccupied.

Other *Chaetura*

As Lack (1956: 11) pointed out, there is great uniformity in the nesting habits of this genus as he conceives it. (His recent revision of the genera of swifts draws strong support from their nesting behavior.) The ancestral *Chaetura* nest site is some sort of hollow—tree, cave or mine boring—which the birds usually enter by fluttering in from above.

Six species (5 as Lack defines the genus) are now known to occupy man's structures: *pelagica, vauxi, andrei, brachyura, ussheri* and *bohmi. C. pelagica* commonly nests in chimneys and other manmade structures. Its nearest relative, *vauxi* of western United States and the Southern Hemisphere, is still essentially a hollow tree nester. The subspecies *vauxi* began to resort to chimneys during this century, though recorded observations are scant. Finley (1924: 6) described a nest built in a boiler at a nursery in California. To reach their nests the adults dropped down a metal flue pipe 60 feet high. A nest that Davis (1937: 222) found in Washing-

ton was attached to a corner of a brick chimney a foot below the roof level. A note by Munro (1919: 234) told of several pairs of these swifts nesting under the roof of a water tank along the Canadian Pacific Railroad in British Columbia.

According to Sick (1950: 425) *Chaetura andrei meridionalis* usually nests in the hollow trunks of Burity palms (*Mauritia vinifera*). In 1948 he established for the first time that the bird occasionally resorts to chimneys. Dr. Sick's paper, translated from the Portugese for me by Mrs. Abendroth, contains a provocative thought which merits repetition here. He says (pp. 427-428):

> . . . it seems certain that *Chaetura* feels strong attraction for chimneys and that in some cases the swift prefers a chimney to a tree-hollow. That seems especially true of *Chaetura andrei* since it comes to town in spite of abundant hollow tree trunks in its home in the Brazilian wilderness. If a few swifts of a flock turn to chimneys the rest of the population may easily follow suit. It would suffice that one bird copy the example of a mate hatched in a chimney and at breeding time look for a place like the one it was born in. However, a single instance of learned habit as the one just pointed out is not likely to be the sole incentive of such behavior. A given population may certainly follow a local tradition, but the tendency itself has probably deeper roots that reach far back into the past and have caused similar tendencies to develop in all related members, even though each one may follow its own peculiar way of putting it to work. In other words, the species, perhaps all the genus *Chaetura*, may possess an inborn urge to act in this manner. This way of looking at the problem would explain why the swifts in question take so readily to chimneys . . . I think that *Chaetura* was virtually a chimney-breeder before the first smokestack was built in America . . . Therefore what may look like a change in the fixed nesting habit of a given species may be merely the bird's reaction, conditioned by its own inborn trend, to a different environment. That is to say, response to the new surroundings will be within the limits of the bird's inherited abilities. Viewed in this light, *Chaetura's* apparent joining of man does not necessarily mean a change in habit but rather a more ample play of an inborn trend in the face of better opportunities accidentally provided by man's progress.

ARRIVAL IN SPRING

Time and influence of weather

In central and southern New York the chimney swift arrives sometime between April 17 and 24, the exact date, as in the case of most land birds, depending on the weather conditions. The first individuals to appear in an area are evidently migrants headed

for more northerly regions, since a day or more may pass before additional swifts are noted in that locality. Usually these first birds are detected in the late afternoon or evening as they pass over high above and utter an occasional chipper which reveals their presence to the bird watcher.

The weather factor is probably more influential than one would suspect. When I was in Wilmington, North Carolina, on April 2, 1953, chimney swifts were abundant and already courting. They did not reach Ithaca—664 miles away "as the swift flies"—until 28 days later, yet Lowery (1943: 59) and Coffey (1956: 84) have shown that the species can cover 200 or more miles in a day's flight. Tyler (in Bent, 1940: 271) states that while the average arrival date in New Orleans is March 18, the bird does not usually reach New England for another 30 days. The airline distance in this instance is approximately 1,240 miles.

Writing on the effect of weather, James (1950: 10) said, "This spring the large flocks of swifts seemed to occur after cool rainy days and although this may well be coincidence, it has been observed here [at Ithaca] repeatedly in the past."

At Kingston, Ontario, 119 miles north of Ithaca, Bowman (1952: 155) stated that "on the average, the peak of the chimney swift migration at Kingston [as at Ithaca] is reached about the third week of May. When the month of May is warm and dry, the swift migration appears to be steady, with regular nightly roosting in Fleming Hall chimney. During rainy weather small flocks arriving at the chimney apparently remain there until the weather clears. As many as 4,000 swifts have been observed to accumulate over a 3- or 4-day rainy period."

In their work with the common swift (*Apus a. apus*) in England, the Lacks (1952: 188) once noted a lapse of nine days between the arrivals of resident birds, which they presumed was due to a holdup on the migration route.

Arrival in the study area

In May of 1952 I was able to study the arrival of chimney swifts in the study area. The first swift of the year at Ithaca was recorded on April 21. As I passed through Binghamton, New York, 37 miles southeastward on the way to Beaver Kill, I saw a flock of approximately 75 birds milling about over the city at 5 p.m. on May 1. The weather until that date was normal, but the remainder of the month turned out to be most backward seasonally. Cold days with overcast skies or rain were the rule, so the movement into and

through the area, while not normal or representative, did indicate the influence of inclement weather.

Chimney swifts did not arrive in the study area in a wave but trickled in gradually. Individuals and groups comprising up to seven birds were noted from the beginning of May, but which of them represented residents and which migrants I cannot say positively. Had I known where every nest site was, it would have been possible to check each one nightly for roosting birds. Since a swift that spends the night at a nest site nearly always represents a resident (and can be color marked as such), most unmarked birds could then have been classed as transients.

Judging by the actions of some individuals, I believe that migrants pass through the study area, but in small numbers. For example, on the evening of May 16 I investigated an abandoned farm near the Beaver Kill Trout Club and at 8:25, with darkness closing in rapidly, I spotted four swifts flying hurriedly and directly down the Beaver Kill. They were 200–300 feet above the water. At that time, the residents must have gone to roost, and I assumed these to be transients seeking a place to pass the night.

Apparently there are no structures in the region suitable as roosts for flocks, for I did not see any concentrations of birds on May mornings. Nor have I ever seen a flock in the fall. Indeed, the largest "flock" captured was taken out of a chimney at the Trout Club on August 21, 1950; it numbered 12 birds, most (probably all) of which represented residents. Clearly, the study area does not lie along one of the species' important migration routes.

Several banded swifts that have returned to Beaver Kill from previous years shed some light on the arrival of the resident population. On May 5 a bird roosted in the smaller barn at the Beaver Kill Trout Club. The next night two swifts roosted there and I captured both; one proved to be No. 668—an individual that had nested (or tried to nest) in the building for the past three years.

There were no swifts in the chimney at the Trout Club on the night of May 19, but on the succeeding days courting birds were observed nearby. When I looked down the chimney after dark on May 22, I was not surprised to find two birds roosting side by side (like a mated pair). Two nights later I captured these birds (presumably) and one, number 615, was a bird that had been raised in that chimney two years earlier. The other received band 627. I do not know where 615 was during the summer of 1951; possibly it did not breed that year. This swift attempted to raise a family in the chimney in 1952, but heavy rains washed the nest

off the wall and the young died. I learned later that the bird was a female.

Numbers 036 and 561, the swifts that had nested on the couch cover in Woelfle's barn during 1950 and 1951, returned to the building on May 18 or 19, and they brought forth their third family together. The Lacks (1952) found that with *Apus a. apus* "in about a quarter of the observed pairs, the two members arrived on the same day."

Flocking and roosting of migrants

As evening approaches, the earlier spring arrivals evince unfamiliarity with a neighborhood through their search for a roost. On May 1, 1953, between 7:25 and 8:20 p.m., I observed a group of 75 transients on the Cornell University campus at Ithaca. As the birds explored the area around the College of Veterinary Medicine for approximately a quarter of a mile in every direction, they moved in a loose flock and chippered loudly and often. Their manner of searching was obvious. The swifts would locate a building with one or more chimneys and by flying in large circles they would pass over it occasionally. They often made between 6 and 10 trips over a possible roost and then took off in a generally straight line for some other place.

By 7:50 the flock was noticeably smaller; it seemed that some of the birds had merely wandered off the campus to look elsewhere, while about 20 appeared to drop into a chimney (which I was unable to see from the ground) atop the Plant Science Building. At 7:55 I saw a group of 20 to 30 suddenly drop into a chimney on one of the Veterinary College buildings. For the next five minutes it seemed as though all the swifts had gone away, but at 8 o'clock a tight-flying group of about a dozen appeared and they were obviously very intent about their roost hunting. The birds flew straight, fast and with relatively little chippering. They "buzzed" the big Roberts Hall chimney a few times; once the flock made a corkscrew drop toward the opening but veered off at the last minute. Then the swifts hurried to the Veterinary School about 400 feet southwest and circled several times over the chimney —which already contained birds. Next they flew toward the east chimney of Bailey Hall, some 600 feet to the north, but as it was then very foggy and nearly dark I lost sight of the group and did not learn where they passed the night.

By the time the peak of the migration arrives, finding a roosting place is less of a problem. As the swift banders have demonstrated,

there is not a mass replacement of one northward migrating flock by another at any particular station but rather a gradual replacement. This means that at each station there are a certain number of swifts familiar with roosting places, and these birds undoubtedly serve as "guides" for the whole flock while in the area. Field observations lend support to this idea; at the height of the migration one sees fewer lone swifts flying about "panicky" and still seeking a place to rest after the others have gone to roost. Parenthetically, I might remark that these stragglers are aided by the birds already in a chimney. The roosting swifts continue to chipper for 15 minutes or more as they settle down for the night, and their notes "decoy" the latecomers.

This occasionally sets up a still more serious problem than that of finding a suitable roosting place, for as a flock increases, perhaps with increments accumulated during unfavorable weather, a favorite chimney sometimes becomes too small. Even with the birds roosting two or three layers thick (Walker, 1944: 46) some swifts must seek another place. At times this can be disastrous—and almost humorous—as Chapman (1922: 210) related years ago. It seems that a Mr. Rice, living in Kingston, New York, was called home one May night when people noticed a huge flock of swifts around his chimney. As he opened the living-room door the rush of birds knocked his glasses off. Covering his face with his arms, Mr. Rice managed to reach the window. When he opened it about 1,500 went out. Next he turned off the light, but when he snapped it on again there were swifts on all the mouldings and pictures. Rice threw them out the window along with a number found behind the pictures and furniture. The swifts had loosened so much soot in the chimney that Mr. Rice had to shovel it up, and the sooty birds had marked all the walls and ceilings with their soiled wings; droppings were everywhere. Two days later, writes Mr. Rice, the swifts were still in the chimney, and when he made a paper fire in the fireplace they drove the smoke down again with their wings! He examined the furnace in the cellar only to find about 50 live and 50 dead swifts in it. In addition, he removed 10 water pails of dead birds from the pipes and bottom of the chimney.

At the peak of migration, the chimney swift frequently attracts attention by its unique flocking behavior. Typically, this is somewhat as follows: Sometime after 6 o'clock on a pleasant evening, swifts begin to gather in the neighborhood of the chimney that will be their roost. Generally this is a favorite one that the birds have used for many successive seasons. The swifts do a great deal

of calling as they fly rapidly about in the initial flocking period. Judging by their occasional jerky sideward movements, the birds feed at this time. After the sun has set, and during the hour before darkness, the birds assemble in a huge, doughnut-shaped flock and the entire mass revolves in the air over or near the chimney. Within the next 15 minutes the descent into the roost begins, a few birds at a time at first and then many so precipitately that the flock looks like a column of smoke going back into the chimney. Pearson (1911: 115) writes of a flock of 1,000 birds that poured into a chimney in North Carolina in less than 20 minutes. It is indeed an amazing sight, hence the literature abounds with accounts of the spectacle. Linton (1924: 252-253), Pickens (1935: 149-153), and Groskin (1945: 361-370) have also published good descriptions of it.

Chimney swifts on occasion do not enter their roost this way, as Calhoun (1938: 78) was first to point out: instead they gather in the vicinity and, dispensing with the doughnut-shaped formation, enter the roost more or less steadily. My observations suggest that swifts often employ this method when the weather is inclement.

A number of authors have commented on the swift's altering its behavior in the face of poor weather in spring as well as in fall. A flock might remain in its chimney longer on a cold morning (Musselman, 1926: 121). Sutton (1927: 265), studying spring flocking at Washington, Iowa, saw a flock emerge from a chimney early on a "very chilly" morning; after flying about for awhile, the birds went back into the roost at 8 a. m. During rainy, cool weather in May at Ithaca, James (1950: 9) found that the swifts went to roost earlier in the evening, and on one occasion several hundred entered a chimney at midday.

On September 5, 1926, a flock of over 100 individuals roosted in close formation on the bark of an oak tree at Cold Spring, New York (E. K. and D. Campbell, 1926).

RETURNS TO THE STUDY AREA

In connection with these studies of the chimney swift, I banded 61 adults and 97 nestlings or immature birds, giving a total of 158. A great many of the banded birds returned in subsequent years and shed light on such matters as the instinct to return to previous nest sites or hatch places, the change of breeding sites, remating, when young birds breed for the first time and longevity—matters for discussion here.

Return instinct

In adults

The first chimney swift banding in North America was evidently done by Howard L. Wood (1901: 194) at Groton, Connecticut. In 1881 he put rings of copper wire on the legs of a pair nesting in his father's barn. For the next five years, Wood wrote, the same pair occupied the same nest. One of the adults was still present in 1890.

Among the 58 adult chimney swifts which I banded through 1952, and which therefore have had an opportunity to return, 27 or 46.6 percent came back to the study area. The percentage in this instance does not present a true picture of the bird's strong tendency to return to a former *nest site*. When we consider the number of adult swifts banded at their nests—40— and compare it with the total number of returns captured at nests—25—the percentage is 62.5, which is much more indicative. This recalculation must be made owing to the fact that each year, toward the close of the summer when families were breaking up and wandering about the study area, I sometimes caught mature individuals that experience showed I was not likely to capture again. In addition, 2 (and possibly 4) birds were banded too early in the season to be classed positively as birds at their nest sites. As a matter of fact, only 2 of the 18 adults, (or 11.1 percent) not banded at their nests through 1952 provided return data.

Returns to previous nest sites

Nineteen of the 27 adult returns (70.4 percent) were birds that came back to their previous nest sites and never nested elsewhere (unless they did so before I banded them). This strong tendency of the adult chimney swift to return to a former nest site is supported by Dexter's findings (1952: 73-74; 1953: 17-18; 1954: 60-61; 1956*a*: 83-84).

In Europe, Schifferli (1936: 82-85) found that adults of the common swift (*Apus a. apus*) return faithfully to their nesting sites and usually to the same boxes, pairs often nesting together for many years. Sometimes they did change mates.

The Lacks (1952: 188) cited Weitnauer as saying that in his experience "common swifts tended to return to the same nest sites in successive years and that, probably for this reason, the same pairs tended to breed together in successive years." Because they discontinued banding the adults, the Lacks could not precisely

determine the return and remating aspects of the common swifts they worked with, though they did learn that some birds returned to occupy previous nest sites with previous mates, while other individuals changed sites and mates, possibly because of human disturbances.

Neither Dexter nor I found a sexual difference in the strength of the return instinct.

Remating

My findings relative to remating are in line with those of Dexter, Schifferli, and the Lacks. As reference to table 2 will show, it was usual for the Beaver Kill chimney swifts to renest with former mates. (Considering their strong tendency to return to the previous nest site, it would appear unusual if adults did *not* remate.) Of 7 pairs of swifts, 2 were mated for three successive summers and 5 mated consecutively for two seasons, giving a total of 9 rematings. I found no instances wherein both previously mated birds returned and each chose a new mate and a new nest site, although Dexter occasionally has found this situation.

There was one case in which a change of mates occurred while both former partners were still living. Number 561, hatched at Tract A in 1946, nested (possibly for its first time) at Tract C in 1948; its mate was 648. They raised their second brood there in 1949. In 1950, however, 648 went to Tract A, where it had never nested before, and mated with 041, an unbanded swift. Meanwhile, 561 remained at Tract C, got a new mate (036) and continued to nest there with it through 1952. However, Dexter's data indicates that this was not an uncommon occurrence.

Failure to return to nest site

The eight birds that did not always return to their previous nest sites give us further insight into the species' behavior. Let us consider them.

First are the records of the swifts numbered 614 and 615; both were captured for the first time on August 21, 1950, along with 7 other adults (2 of which bore bands) and 2 immatures, in the chimney at Tract B. Concerning the 2 banded individuals, 1, a return to the Tract, had come over from another site; the other was a parent of the 2 immatures. I did not capture 614 again until July 7, 1952, when it was nesting with number 615 in the same chimney. After a heavy rain had washed their nest down and the four young died, I killed number 615 to learn its sex—it was a female; therefore, 614 was a male.

In 1953, number 614 returned to nest in that chimney with number 618 which, incidentally, was one of the adults banded along with 614 on August 21, 1950. When captured at their nest on July 1, 1953, it was the first time I had retaken 618 after I banded it. Since both were adults when I banded them and since neither had nested in the chimney during 1950, they could fall into any of the following categories: (1) They may have been hatched in the chimney (or elsewhere) the previous year and may (or may not) have been nonbreeding birds. (2) Possibly one or both had nested in the chimney before, and this accordingly represented a return to a former site. (3) Maybe each had nested elsewhere in the study area in sites unknown or inaccessible to me, and their capture disclosed a change of nest site.

Next is the record of number 648, a female swift banded in 1948 while nesting on the couch cover at Tract C. Its mate—561—was born in the silo at Tract A, two years before; this was his first nesting at Tract C, for I did not retake him during 1947. Number 648 was a newcomer to the couch cover site. Both individuals returned to it in 1949 and raised another family. But in 1950, 648 went over to the silo and bred with a new unbanded male, while 561 got a new mate—number 036.

The silo was removed in late 1950, yet 648 returned to the barn in 1951 where I captured it without a mate on June 21. I felt quite sure that it was not going to breed. Anxious to know the sex of this bird—so that I could determine that of several others—I killed 648 and learned it was a female.

The remaining five adult chimney swifts are those that *never* went back to the nest sites at which they were originally banded. First is number 646. This individual was banded in the smaller barn at Tract B, where it bred, in 1948. The mate was a return to the building from the year before. While not taken in 1949, it is possible that 646 occupied the chimney at the Tract since the chimney was not examined that year. In 1950, 646 *was* captured in the chimney on August 1 and 21. On the earlier date there were three young in a nest, but two other unbanded adults were also present. One of these (banded 607) was not there on August 21, so the other (number 608) was likely the mate of 646. Unfortunately, none of the three has returned to the study area to verify this presumption.

Number 706 concerns us next. Banded at Tract E in 1944 (its mate escaping capture), this swift was not recorded in 1945. In 1946 it nested in the Tract A silo with number 091. Swifts used the silo in 1947; on August 4 I captured two birds, which I num-

bered 604 and 605, but a third banded swift escaped. An adult (banded?) also evaded me on August 14. I feel that the unkown bird was actually 706 for two reasons: (1) In 1948, 706 returned there to breed with 605. (2) 706 came back in 1949, but on the one occasion that I handled the bird (July 16) I took it with two other adults, so I cannot say positively that it was a parent. (More is said of this sort of incident in the section on "Three birds at a nest.") I did not recapture 706 after 1949.

Third is swift number 053. This was one of those birds unfortunate enough to select Mrs. Huske's chimney as a nest site. When she came to Beaver Kill for the summer of 1950, 053 and its presumed mate 052 left the smoke-filled chimney. On August 1, I recaptured 052 with several other (flocking) adults in the Tract B chimney—the only retake for the bird. Number 053 was not caught again until June 13, 1951, when, interestingly enough, it was in the Tract B chimney mated to 619. Their nesting was unsuccessful, however, and neither has been handled again.

When Mrs. Emery told me in 1948 that she found a brood of dead young in the chimney at Tract B, I decided to catch the adults. So, on the evening of August 16, just after they went to roost, I smoked up the fireplace enough to drive them out. Both went over to the smaller barn, some 225 feet away, where I captured them and affixed bands 668 and 669. The latter I caught no further, but for the next four summers 668 returned to the building in which it was captured. It raised young in 1949 and 1950. In 1951 I captured the bird too soon, so it and its mate deserted the eggs. Probably 668 would have nested there in 1952, but it and its presumed mate deserted the site before egg-laying occurred because of too early handling. I had color marked them and obtained their weights and temperatures. Number 668 was seen courting three days later (May 9) and roosted alone at the nest site that night, but was never observed again. The site went untenanted in 1952. I did not expect either of the 1952 birds to return to it in 1953 and was prepared for what followed: The site was unoccupied during 1953 and 1954. This underscored the fact that an otherwise suitable nesting place was not likely to be used unless one of its last year's occupants returned to it.

Last is the record of the bird that has done the most wandering —number 091. I banded it in Woelfle's woodhouse in 1942 with its young; the mate escaped. On May 15, 1943, the bird went down Mr. Banks' chimney into the living room and he caught it. Where 091 passed that summer I do not know. Thanks to the gasoline rationing, it was able to rear a brood in Huske's chimney in 1944.

Instead of returning there in 1945, it went to the Tract A silo about 800 feet west and raised a family in 1945 and 1946. I saw no more of it after that.

Return instinct in the young

Of the 92 chimney swifts banded as nestlings, 10 (10.8 percent) were subsequently recaptured in the study area; 8 of them definitely bred while the others may or may not have done so.

My return percentages are rather higher than those for most passerine birds (cf. Baldwin and Kendeigh, 1937: 115; Farner, 1945: 85; and Keurzi, 1941: 41) and possibly for swifts in general. Schifferli (1936) stated that young of the common swift (*Apus a. apus*) do not regularly return to their birthplaces. Lack and Arn (1947: 208) who studied the Alpine swift (*Apus melba*) found that while a few young breed in their first summer, they usually bred for the first time in their second summer after hatching. The Lacks (1952) believed that most of the nonbreeding common swifts they worked with were one-year old birds, and they cite Weitnauer (1947) as saying that although first-year birds of this species formed pairs and occupied nest sites, they did not normally breed.

Returns of young to hatchplaces and beginning of breeding

Five of the 10 young returns went to their own hatchplaces in the summer following birth and nested in their first summers. Actually, 1 of these 5 left its hatchplace at Tract C because of my interference early in the summer and nested at Tract F.

Three birds that were not retaken in the summer following hatching support the hypothesis that not all young chimney swifts breed in their first summer. These 3 were each recaptured in their second summers, at which time they were nesting, 2 of them at the nest sites in which they were hatched. One of the 2 birds was later determined to be a female. The third young swift, which later proved to be a male, was hatched in the Tract A silo and two years later—and every year through 1952—nested in Woelfle's barn.

I have now discussed 8 of the 10 returns. Whether the remaining 2 nested or not is indefinite. One nestling that I banded number 652 in Virtue's woodhouse (Tract F) in 1948 was back in the area in 1949; I caught it in the Tract A silo on July 16 with 2 other swifts—numbers 569 and 706. Number 569 was the bird that was hatched at Tract C, returned to nest the next summer, but left and bred at Tract F because of my interference. It had nested in

the woodhouse in 1947 and 1948 and it was odd that it should be in the silo on July 16, 1949, unless it were one of the pair raising young there. I believe it was. Number 706, it will be recalled, while not originally banded at the silo did nest there in 1946, probably in 1947 and definitely in 1948. Therefore, it—like 569—was a bird with an attachment to the area and with a known record for nesting. On the other hand, 652, born in 1948, was evidently a wanderer and may never have bred, for these reasons: (1) I believe that 569 and 706 represented the paired birds. Unfortunately, I was able to catch them only once, though my notes state that only two birds were present in the silo at night on July 3 and 23, and only on the 23d were 3 birds there (when I captured all of them). And (2) I obtained only one recapture of 652 in 1950. During that season I had feather-marked the silo birds, and had made nightly examinations of the site for strange swifts. On July 22, a date at which all the known swifts had young, number 652 wandered into the silo. I did not handle it thereafter.

The other nestling that may or may not have nested was number 558. Banded in 1946 in the smaller barn at Tract B, it returned there the next spring. I captured it on May 30 in company with 595 and 556, the latter a return to the barn from the year before. However, handling the birds disturbed them too much—all left the site and it went unused. Number 558 has not reappeared.

Mating with own parents

Among the 10 returns are 3 (numbers 558, 696 and 784) that came back to their hatchplaces with one or both parents. Since it is unlikely that the young were actually physically mated with the parents, I have reserved discussion of their cases for the section titled "Three birds at a nest."

For a clue to what might happen should both an adult and one of its young of the previous year return to the hatchplace, there is the record of 087 and its parent, 092. They returned to the larger barn at Tract B in 1943. This was during the brief period when *two* pairs of swifts were occupying the site. Instead of mating with its parent, 087 paired with an unbanded bird (310) and nested in the east gable while 092 remated with its partner of the year before and brought off young in the south gable.

An exasperating experience robbed me of the best opportunity to learn if a young bird that returned to the hatchplace would breed with a parent that also returned there. The instance involved number 569, born of 567 and 4608 at Tract C in 1946. On May 30, 1947, I took 567 and 569 as returns to the nest site. At that

time I was working on a method of sexing live swifts, and the thorough examination I gave the birds proved too much for them. Both left the site! Number 569 moved to Tract F and nested. Number 567 disappeared forever. In view of the high return tendency of both adults and juveniles it would not be surprising to find an occasional mating between a parent and its own young. However, I found no such instances reported by Dexter in his numerous papers on the species.

It may be that the young swifts normally mate with older birds for their first nesting. The only evidence I have for this is the case of number 615. The bird was banded in 1950 as a nestling. I recaptured it for the first time in 1952, at its hatchplace, with a banded swift (614) known to have been an adult in 1950. The birds mated in 1952.

Résumé of site occupancy

To bring this mass of return data into a unified whole, to extricate it from the narrative and thereby make it readily available to other workers, and to reemphasize how strong is the chimney swift's return instinct, I have summarized the occupancy records of all sites in the study area in table 2.

Although chimney swifts sometimes nest close together in large numbers—as they do in the air shafts at Kent State University in Ohio—and though they exhibit a strong return instinct, the species is not a true colonial bird. Colonial nesters are seldom found singly or in a few pairs. Indications are that their whole reproductive efficiency is improved through their close association. Along with the evolution of the colony-nesting habit has gone a selection for birds—adults as well as young—that have an innate tendency to return to the breeding territory. (One might reason just as strongly in the other direction and insist that natural selection, by weeding out individuals that lack the instinct to return to the old nest or hatch place, has led to colony nesting.)

It is beyond my purpose to enter into that discussion. Suffice it to say that there is no evidence to show that the chimney swift's reproductive efficiency varies between isolated individuals and those breeding in proximity to one another. While this research has demonstrated a very high return percentage for adult swifts, comparable to that which Austin (1942: 160-161) found for the colony-nesting common tern (*Sterna hirundo*), I doubt that it is actually higher than that of most small land birds. Chimney swifts, like hole-nesters and other birds which nest in buildings, have

TABLE 2

Occupancy Records of Chimney Swift Nest Sites

YEAR	TRACTS A	B	B′	B″	B‴	C	C′	D	E	F	G
1939	584 & ?	588 & ?									
1940		588 & ?									
1941	936 & 937	588 & 365	Empty	092 & 004							
1942	936 & 574	588 & 076	Empty	092 & 084			091 & ?				
1943	Empty	588 & 076	087 & 310	092 & 084			Not Habitable				
1944	Empty	582 & 076	696 & 310	092 & 098			Not Habitable	091 & 269	706 & ?		
1945	091 & 612	076 No Nesting	Empty	Empty		4608 & 611	Not Habitable	? ?	Empty		
1946	091 & 706	272 & 556	Empty	Empty		4608 & 611	Not Habitable		Empty	? ?	
1947	605 & 604	558 & 556 & 595—No Nesting	Empty	Empty		569 & 567	Not Habitable		Empty	569 & 606	Empty
1948	605 & 706	595 & 646	Empty	Empty	668 & 669	561 & 648	Not Habitable		Empty	569 & 647	654 & 664
1949	569 & 706	668 & 777	Empty	Empty	? ?	561 & 648	Not Habitable		Empty	789 & 790	654 & 664
1950	648 & 041	668 & 777	Empty	Empty	5608* & 646*	561 & 036	Not Habitable		Empty	789 & 790	Empty
1951	Not Habitable	668 & 777	Empty	Empty	053 & 619	561 & 036	Not Habitable		Not Habitable	Empty	Empty
1952	Not Habitable	668—No Nesting	Empty	Empty	614 & 615	561 & 036	Not Habitable		Not Habitable	Empty	Empty
1953	Not Habitable	Empty	Empty	Empty	614 & 618	Empty	Not Habitable		Not Habitable	Empty	Empty

Key: A — Tract A silo (Ackerly Farm)
B — Tract B, smaller barn (Beaver Kill Trout Club)
B′ — Tract B, larger barn, east gable (Beaver Kill Trout Club)
B″ — Tract B, larger barn, south gable (Beaver Kill Trout Club)
B‴— Tract B chimney (Beaver Kill Trout Club)
C — Tract C barn (Woelfle's Farm)
C′ — Tract C woodhouse (Woelfle's Farm)
D — Tract D chimney (Huske's Place)
E — Tract E barn (Ragan Farm)
F — Tract F woodhouse (Virtue's Place)
G — Tract G silo (Jewett Allen's Farm)
Numbers refer to number of each identified bird.

specialized site requirements which make them relatively easy to capture (cf. Fischer, 1944). Banders who concentrate their efforts on a few such species in a limited area have consistently obtained numerous returns. In her monumental work on the song sparrow (*Melospiza melodia euphonia*), Mrs. Nice (1937: 177) cited a 46 percent return of adult barn swallows (*Hirundo rustica gutturalis*) and red-rumped swallows (*Hirundo daurica nipalensis*) by Uchida (1932: 1-11), 48 to 52 percent of adult tree swallows (*Iridoprocne bicolor*) by Low (1934: 24-30; 1933: 76-87), 52.4 percent of adult plain titmice (*Baeolophus i. inornatus*) by Price (1936: 23-28), and 49.6 percent of adult starlings (*Sturnus v. vulgaris*) by Kluijver (1935: 133-166).

Mrs. Nice is among the very few who have concentrated on a species that did not nest in a building or in a natural cavity. She calculated a theoretical return percentage of 60 (Nice, 1937: 166-177) for the song sparrow.

Longevity

The 27 returns, plus one bird that died during the summer in which it was banded, have provided some data (see table 3) on life expectancy in the chimney swift.

TABLE 3
Longevity in the Chimney Swift

BANDED AS	AGES THEY ATTAINED					
	1	2	3	4	5	6
Adult	1†	15	5	3*	3	1
Young	4	3	2			

* — including one deliberately killed.
† — found dead in the summer it was banded.

The ages for swifts banded as adults are only approximate, since there was no way of telling how old birds were when I captured them for banding. The two- and three-year age classes for both adults and young probably are inaccurate in view of Green's (1940: 51) evidence that few chimney swifts live more than four years. Had my study lasted longer, but with no new banding, some of the birds entered in these classes would have been moved to higher categories.

Green (1940: 37) banded 17,165 chimney swifts in the region of Chattanooga, Tennessee, between 1928 and 1930. Professor Green moved from Tennessee, apparently after the 1930 banding season. He waited until 1940 (for the last of the recoveries to be reported) before publishing his results. In all, he had 732 returns and 327 recoveries.

Dr. Green felt (1940: 51-52) that "perhaps more than a fourth of the swifts die each year of old age . . . and it seems likely that a large proportion die between two and three years of age." Bowman (1952: 156) stated that his comparative data from Kingston, Ontario, did not support Green. On analyzing Bowman's data on 2,480 returns and recoveries (p. 158) I found that there was approximately a 50 percent annual average mortality in each age class. That is—and these are Bowman's figures—after one year of banding he had a total of 1,141 returns and recoveries. In the second year the total had dropped to 521, a decrease of 46 percent. In the third year the total was 312, a decrease of 59 percent.

Ben Coffey, whose total of more than 81,000 has established him as the leading chimney swift bander in the United States, has sent me a digest of his 3,114 returns. They also suggest an annual mortality rate of approximately 50 percent. Therefore, the proportion that die between two and three years is probably no greater than the proportion that die between any other age groups.

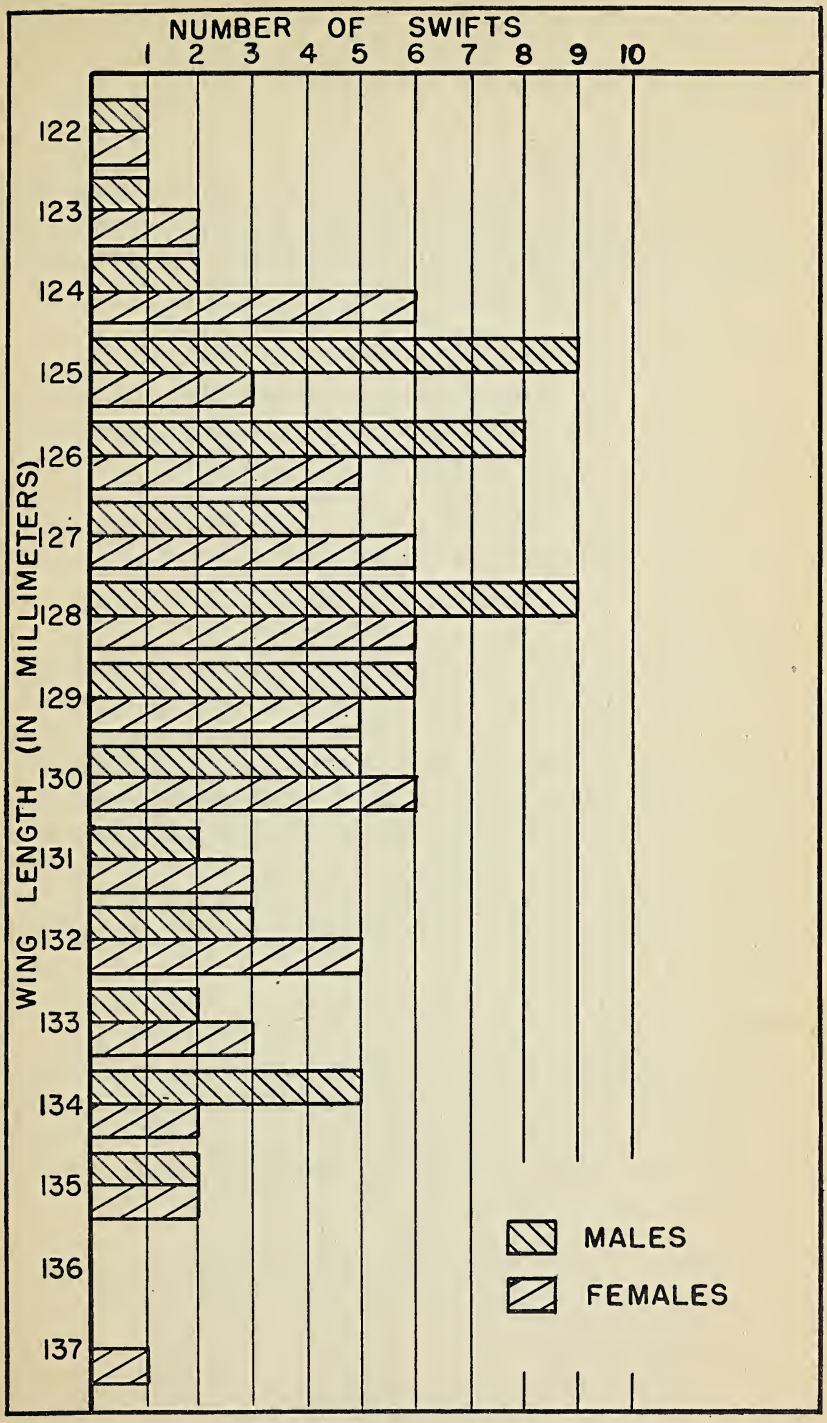
However, my data and those of Bowman, Coffey and Pond (1940: 39), who reviewed and recalculated Green's age-class data, support Professor Green's contention that few swifts live beyond four years. Only 5 percent of Green's birds exceeded four years. Seven percent of Coffey's swifts lived longer than four years. Bowman's figure of 13 percent came very close to mine (14 percent), but this was most likely accidental. Since these last two percentages were derived from samples smaller than Coffey's they are probably less accurate than his.

At this writing the oldest chimney swift on record is number 38-87838. R. W. Smith banded it at Kingston, Ontario, on May 18, 1940. Gordon L. Hight, Jr. recaptured it at Rome, Georgia, on September 21, 1952. Since the bird was an adult when banded, it had attained at least 13 years (Hight, 1953: 109-110).

Single examples of 11-year-old swifts were listed by Cooke (1946: 69), Bowman (1952: 158), Green (Pond, 1940: 39), Laskey (1943: 6), and Dexter (1956b: 276). Ten years were attained by three of Coffey's birds (personal communication), two of Bowman's (1952), one of Green's (Pond, 1940), and one of Musselman's (Cooke, 1942: 73).

ATTEMPTS AT SEX DETERMINATION

Sexual dimorphism is almost totally absent in the swift family. The genus *Cypseloides*—and so far as I know it is the only genus—contains a species (*rutila*) in which the female lacks the rufous



Graph 1. Sex versus wing length

collar of the male (Blake, 1953: 235). None of the specialists on the group has devised a method of determining the sex of a living swift in which the sexes are morphologically similar.

Physical characteristics

If there are physical characteristics of the chimney swift that are correlated with sex (I feel there are) these studies have not conclusively demonstrated them. Nevertheless, the considerable data I accumulated do suggest certain relationships.

The internostril area

For a time I thought there might be a clue in the area between the nostrils. In some individuals this was a definite, raised ridge whereas in other swifts the internostril area was flat. As I examined more swifts, specimens appeared which were borderline cases, and in one instance I designated the area as flat one year but raised the next. Hence, this character was not considered useful.

Wing length

Wing length, so helpful in sexing passerines, bears no relationship to sex in the chimney swift so far as present data indicate. To investigate this matter, I measured specimens from Cornell University, the American Museum of Natural History, the United States National Museum, the Museum of Comparative Zoology and the Museum of Vertebrate Zoology. When added to live birds of known sex that I had measured, the number of measurements was 116. From the frequency distribution (see graph 1) it is evident that, for these data at least, wing length and sex are not correlated in this swift.

Weight

Since we know that weight is correlated with sex in the passerines, I thought a similar relationship might hold in the chimney swift, which is separated from the Passeres only by the Order Pici (Mayr and Amadon, 1951: 35). With the birds at Tract C

TABLE 4
Weights of Chimney Swifts Mated Three Consecutive Years

DATE	MALE — #561	FEMALE — #036
July 10, 1950	24.2	.....
Aug. 3, 1950	.....	24.9
June 13, 1951	24.0	25.5
July 6, 1952	22.4	24.4

(Weights in grams)

there was a positive correlation during each of the three years they were mated, the female being the heavier. The following table is a condensation of their data.

During the summers of 1951 and 1952 I obtained series of weighings of this pair. In 1951 their weights fell in a generally regular progression thus:

TABLE 5
Weights of Mated Chimney Swifts: 1951

DATE	MALE — #561	FEMALE — #036
June 13	24.0	25.5
July 1	.....	25.6
July 8	24.0	24.6
July 13	.....	24.7
July 17	.....	24.6
July 19	22.2	23.4
July 20	22.8	24.5
July 22	.....	24.6
July 24	22.5	24.4

(Weights in grams)

The picture presented in table 5 is what one would expect in view of the fact that passerine weights are highest during migration. According to Mrs. Ben B. Coffey's unpublished data, the swift's weight evidently rises again after breeding. Some of the weights she has recorded are higher than any I have obtained or found in the literature.

In 1952 there was not the steady weight decrease for this pair as the summer wore on. Since bird weights vary from day to day, perhaps I was unfortunate enough to weigh these swifts on days when their weights were abnormally high. In the tabular presentation of their data which follows, it will be noted that on each of the four days on which *both* adults were weighed, the female was heavier.

During 1952 I weighed a second pair of swifts (at Tract B) whose sexes were known. The male was 25.1 grams while its mate was 26.9. Perhaps it is worthy of note that while each female (the one at Tract C and that at Tract B) was heavier than her mate,

TABLE 6
Weights of Mated Chimney Swifts: 1952

DATE	MALE — #561	FEMALE — #036
July 6	22.4	24.4
July 15	23.4	24.3
July 19	.....	24.9
July 23	22.4	24.8
July 26	23.0	25.0
July 29	.....	23.4
Aug. 3	.....	24.8

(Weights in grams)

the Tract C male was heavier than the Tract B female. This led me to wonder whether a female's weight *relative* to that of her mate is more important than her actual weight as compared with that of other females, or males.

Information on the weights of chimney swifts is extremely scarce, while data on the weights of individuals of known sex (= museum specimens) is almost nonexistent. I appear to be the only one to have weighed *living* individuals of known sex.

Bartlett (1952: 157-159) weighed 72 live swifts in 1950, which at that time exceeded the total of all other workers combined. He took the birds from a chimney in Massachusetts on May 28 and 29—at the time when their weights would be at maxima. Professor Bartlett caught the birds after a night's roosting (during which each would have lost approximately two grams weight) so his figures may be a trifle low. He gave minimum, maximum and mean weights of 20, 27 and 24.9 grams. A frequency distribution graph of his weights gives a normal curve indicating, for his sample, that there is no sexual difference.

Earlier, Stewart (1937: 326-327) had examined 47 birds for which he gave minimum, maximum and mean weights of 21, 27, and 23.3 grams. Through correspondence with Professor Stewart I learned that his data came from living swifts; all but one were caught in a chimney during August and weighed near midnight. Thus, their weights would have been at maxima for that day, but lower than they would be at the beginning of the breeding season. The "odd" bird was caught in a room in an unoccupied house in May. Since Dr. Stewart did not give a frequency distribution in his paper, I cannot say whether or not there was sexual dimorphism in his sample.

In the Cornell University collection are 12 specimens with weights on their labels. All were taken in May and most likely represent both migrants and residents. Their data are as follows:

TABLE 7
Weights of Chimney Swifts Taken in May at Ithaca, New York

MALES	FEMALES
22.9 (C)	18.4
24.4	19.4 (C)
26.0	19.6 (B)
26.8	22.0
26.8	22.4
	25.0
	25.5

(Weights in grams)

Key: B — found stunned in building C — captured in chimney after roosting

The average of the five males is 25.4 grams while that of the seven females is 21.8. Taking the 12 specimens as a group, the average is 23.3 grams, which *appears* to be identical to Stewart's figure. Actually, the birds taken from chimneys and found in a building were undoubtedly underweight; hence, their weights introduce a slight error. If they be discarded, the remaining eight average 23.8 grams, a figure midway between those of Stewart and Bartlett.

It is evident that more data are needed before we can say with assurance that sex and weight are correlated.

Temperature

In their classic work on "Physiology of the Temperature of Birds," Baldwin and Kendeigh demonstrated that the female house wren (*Troglodytes a. aedon*) has a higher temperature than the male. They further stated (1932: 33) that "there is evidence all through the records obtained from passeriform species that higher temperatures occur in the females than in the males."

Hoping this relationship might hold with the chimney swift, I began in 1951 to take the temperatures of adults. In that first year I obtained the following readings for the Tract C pair:

TABLE 8
Weights and Temperatures of Mated Chimney Swifts: 1951

	MALE — #561		FEMALE — #036	
DATE	WEIGHT	TEMP.	WEIGHT	TEMP.
July 19	22.2	106.9	23.4	107.9
July 20	22.8	106.8	24.5	108.4
July 24	22.5	110.4	24.4	109.1

(Weights in grams, temperatures in degrees F.)

Ignoring the entry under July 24 (which I included for completeness, but see below) the data above exhibit a positive correlation between temperatures and sex, and between temperature and weight. I took the July 19 and 20 temperature readings at night, several hours after the swifts had gone to roost. Since enough time had elapsed for the birds to have digested their last meals, the readings must be at or close to standard temperatures.

The July 24 data I obtained at 3 o'clock in the afternoon, after chasing the birds about the barn. Therefore, their temperatures were elevated as a result of muscular activity and they were far above standard. It is interesting to note that their weights were nevertheless directly related to their sexes.

In the course of these studies I had several desertions because of excessive handling, so I was reluctant to meddle with the Tract

C swifts, especially with the high-strung male. On four occasions I took weights and temperatures of both swifts after dark and obtained the following:

TABLE 9

Weights and Temperatures of Mated Chimney Swifts: 1952 (Tract C)

	MALE — #561		FEMALE — #036	
DATE	WEIGHT	TEMP.	WEIGHT	TEMP.
July 5	22.4	109.5	24.4	109.0
July 15	23.4	108.8	25.3	109.0
July 19	.....	.....	24.9	108.9
July 23	22.4	108.9	24.8	109.0
July 26	23.0	109.5	25.0	108.6
July 29	.....	.....	23.4	108.2
Aug. 3	.....	.....	24.8	109.4

(Weights in grams, temperatures in degrees F.)

In table 9 there is no evident correlation between sex and temperature. However, I believe this lack of correlation is more apparent than real—because of the male's temperament.

This individual was easily frightened and when taken in the hand usually uttered a unique squeal which, to persons who sometimes came to see my work, sounded as though the bird were being tortured. And once captured, it exerted constant efforts to free itself. Since muscular exertion results in increased metabolism, the bird's temperature readings were all a bit high. The female was, on the other hand, a very docile swift that permitted capture and examination with little struggling. Indeed, even if the male gave no cries when captured at night, I could always tell which bird I was holding merely by noting its degree of composure.

The thesis that this male's temperatures are abnormal is supported by other evidence. Baldwin and Kendeigh *(ibid.)* have shown that in the house wren the higher standard temperature of the female goes along with her greater weight. They presented no evidence or statement to the effect that this does not hold for all passerines and for families closely allied to them, and it is my guess that it probably does.

If table 9 be examined, it will be seen that a change in the female's weight was accompanied by a corresponding change in temperature on three out of six occasions. (Data for this bird in 1951 showed that temperature and weight varied directly in four out of five times that changes were recorded.) As table 9 shows, there was no positive correlation for the male. For three weight changes there was but one concurrent temperature change. (In 1951, temperature and weight varied inversely on both of two occasions for this bird.) During the three years these swifts were

mated the female averaged heavier each year. In addition her temperature was higher in the two summers for which reliable data are available.

Temperature differences between mated swifts examined during these studies were often only a few tenths of a degree, but, as Baldwin and Kendeigh demonstrated, such small differences are diagnostic.

During the 1952 breeding season I also obtained nocturnal data on a pair of swifts in the chimney at Tract B. See table 10.

TABLE 10
Weights and Temperatures of Mated Chimney Swifts: 1952 (Tract B)

	MALE — #614		FEMALE — #615	
DATE	WEIGHT	TEMP.	WEIGHT	TEMP.
May 24	.....	.....	26.9	108.3
July 10	25.1	107.3	24.0	107.6

(Weights in grams, temperatures in degrees F.)

Temperature and sex were positively correlated in this pair, although temperature and weight apparently were not. I obtained the data at approximately 10 p. m. on July 10; had I waited until later in the night, it is likely that the weight difference would have been less.

In 1953, I made one two-day visit to the study area and measured two pairs of swifts at night. In one case I knew the sexes because one of the birds was number 614—the male in table 10. The data for this pair are shown in table 11.

TABLE 11
Weights and Temperatures of Mated Chimney Swifts: 1953 (Tract B)

	MALE — #614		FEMALE — #618	
DATE	WEIGHT	TEMP.	WEIGHT	TEMP.
July 1	28.4	108.7	27.8	109.2

(Weights in grams, temperatures in degrees F.)

This pair resembled that of table 10 in that sex and temperature were directly correlated while temperature and weight apparently were not.

For the second pair of 1953 swifts I did not positively know the sexes, for both were unbanded. However, only one bird was on the eggs when I entered the barn at Tract A, and according to past experience this was almost always the female. I captured the bird and kept it separate from the mate. Then I recorded the data shown.

TABLE 12
Weights and Temperatures of Mated Chimney Swifts: 1953 (Tract A)

	MALE (?) – #018		FEMALE (?) – #017	
DATE	WEIGHT	TEMP.	WEIGHT	TEMP.
July 1	24.1	107.9	26.7	108.2

(Weights in grams, temperatures in degrees F.)

If my assumptions for the sexes be correct, then this was another instance in which sex and temperature were positively correlated.

During 1952 I examined five unsexed chimney swifts, three of which, captured at the beginning of breeding, gave usable data. I shall discuss number 627 first.

Although swifts were displaying at Tract B on May 19, there was none in any of the nest sites after dark. The following two days were cold and rainy and there was no display. On May 22—a fine spring day—I noticed that two birds appeared interested in the chimney. When I looked down it after dark, there were two swifts roosting side by side as a mated pair would. I studied display in what I presumed to be these birds on May 23, but did not check the chimney at night. The next day I again observed two swifts displaying in the vicinity of the chimney, so that night I made the tedious climb to the chimney top. The two birds present were not roosting side by side; however, that does not necessarily indicate that they were not in some degree paired because they could have heard me and separated before I looked down into their roost.

One of the swifts was number 627. The other was 615—a bird which I later killed and found to be a female. Since the Tract C birds were back at their nest site and presumably paired on May 21, I feel that 615 and 627 represented paired birds, and that 627 was a male. Number 627 was an insignificant 0.2 grams heavier than 615, and its temperature was 0.6 lower. Unfortunately, handling and painting the birds so early in the breeding season had the usual adverse effect: the pair broke up. Number 615 remained to breed in the chimney, but 627 disappeared permanently.

Swifts numbered 628 and 629 were captured roosting in Mrs. Huske's chimney (Tract D) on June 22, 1952. At that late date the birds were undoubtedly paired, although they had no nest. When the Huskes returned to Beaver Kill for the summer, the birds were driven away and have not been recaptured. There was a difference in their weights and temperatures; 628 weighed 0.4 grams more and had a temperature 0.6 degrees higher than 629. Number 628 was probably the female.

The lowest temperature I have recorded for an adult, breeding chimney swift was 106.9 degrees F. for number 561 (a male) on July 19, 1951. The same individual yielded my highest reading—110.4 degrees on July 24, 1951.

To sum up, there is evidence that sex and temperature are correlated in the chimney swift, females averaging higher than males.

Tail spines

Mrs. Abendroth wrote me that there was a difference in the length of the tail spines in a pair of *Chaetura andrei meridionalis* that she skinned. When I examined a series of chimney swift specimens, I found that there were differences, but they were not correlated with sex.

Cloacal protuberance

When the summer of 1952 was past and I still had not devised a completely reliable method of sexing live chimney swifts, Professor Albert Wolfson published his method of determining breeding condition in living male passerines (1952: 159-165). He obtained motile sperms by gently squeezing the cloacal protuberance. When Dr. Wolfson wrote me that he knew no reason why the method would not succeed with the chimney swift, I tried it on seven birds which I took from their roosting chimney at Ithaca on June 8, 1953.

On the following day I examined the birds. After each attempt to obtain spermatozoa, I killed the individual, labeled it, and placed it in a refrigerator. Then I dissected them. Two of the seven swifts were males with fully enlarged testes, but none yielded sperms. The only bird that did provide sperm cells proved to be a female! Evidently it was mated to one of the males. I assumed that the other five birds were late migrants that were going to pass the night in an established nest site.

As I shall point out later, copulation in this species occurs only during the short egg-laying period. Since the onset of this period varies from year to year in this swift—as in other birds—it would be very difficult to know just when to examine the birds with the assurance that coition had not already taken place. Furthermore, handling the birds in such a way at that critical time would result in many desertions, so even if sexes were determined the knowledge would be of little value.

I think the most practical method of sex determination is to watch the swifts at their nests when building is about half finished.

After copulation has been witnessed, the female can usually be recognized by some slight morphological difference and she can be color-marked for easier identification later.

I feel that the female should be marked first, since I believe she has the stronger attachment to the nest site. Later, when the likelihood of desertion is less, the male may be marked. From my experience, I should say that it is unsafe to obtain temperatures and weights before incubation is half over. In the event that observation is impossible, sex determinations would have to be based on weight, temperature and behavior. When these fail, there remains the most reliable technique of all: killing and dissecting a few selected swifts known to have bred with other banded individuals. Using this stratagem, Dr. Dexter sexed more than 50 percent of his birds.

Behavior as a clue to sex

Incubation at night

During these investigations I noted several behavior traits which seemed to be correlated with sex. In 1950, 1951 and 1952 I visited the different nest sites almost every night throughout the summers. Numerous observations revealed that it was usual for both adults to spend the night on the eggs. However, the female was generally first to get on them. Often the male, though on the nest and pressed against his mate, was not really keeping the eggs warm. Occasionally only one bird would incubate during the night; that individual was almost always the female.

Brooding young at night

In this swift it was the rule for both parents to brood the young at night, yet again the female's position on the nestlings indicated that she did most of the brooding, particularly when the young were very small. Brooding by both parents continued, on the average, until the nestlings were 12 days old.

Attachment to the young

The female of the chimney swift seems to have the stronger attachment to the young. In three instances where one parent left the family group before the other, it was the female that remained with the young longer into the summer. Toward the close of the breeding cycle, when the young had taken to flying outdoors, it was not uncommon to find only the female roosting at the site

with the young after dark. A few nights later the male would roost again with his family. After a few more nights he might disappear again.

"Scolding"

The chimney swift has an interesting way of "scolding" an intruder. When alarmed, a bird will slowly raise its wings until they are nearly perpendicular to the body and fully outstretched. The legs are almost straight, thus holding the swift's body quite far from the surface to which it is clinging. Then the bird leaps backward into flight, and snaps or claps its wings together producing a sound resembling the wing-clapping of a rock dove *(Columba livia)* as it flies off a building. In the short time the swift is in the air it produces from three to six snaps. Almost without exception, the bird lands on the original surface and within two feet of the last place to which it clung. This behavior occurs at all times, but at night (when the birds cannot see their way out of the sites) its duration is much longer.

With the pair that nested three consecutive summers at Tract C, the male did most of the "scolding," but at Tract A in 1950 the female seemed to "scold" more. "Scolding" appeared equally divided between the mates at the 1950 nest in the smaller barn at Tract B.

DISPLAY

Display in the family Apodidae is—and appears destined to remain—poorly understood. Because it takes place largely in the air, often at a distance from the intended nest site and frequently at great speeds, it is an aspect of swift biology particularly difficult to study. Since in all but one species the sexes are similar in appearance, the investigator must color-mark birds of known sex if he is to fathom their behavior. But displaying swifts are seldom in view for more than a few minutes at a time, hence they must be reidentified on each reappearance. When the birds return from a sortie beyond the observer's view, they may fly past him too fast for a new examination. Or, just when the swifts have been reidentified, they may disappear again!

In other swifts

Apus a. apus

The most extensive treatment accorded any swift is that of the Lacks (1952: 196-197) for the common swift, *Apus a. apus,* of

Europe. They state that "the pair is probably formed when the second bird arrives in the box at the beginning of the season" (p. 196). Characteristic activities include an incipient threat display, mutual preening ("the most characteristic display between the pair"), a gentle "clucking" note and duet screaming *(ibid.)*. These have no counterparts in the chimney swift.

Nephoecetes niger borealis

Bent (1940: 256), writing of the northern black swift of western United States, stated that "courtship . . . and apparently copulation also are accomplished on the wing." His only documentation for this was an 11-line paragraph from Rathbun (1925: 502) which, in part, says:

> All may be gliding about when suddenly—perhaps from a far height, a swift will dash at one beneath, this followed by erratic flight actions on the part of both and their disappearance in the distance. This dive I have seen made with such speed that the eye could scarcely follow it, and during the time the birds are darting and twisting about it is a common thing for them to descend almost to the ground.

Chaetura v. vauxi

According to Rathbun (*in* Bent, 1940: 294) the Vaux's swift of western United States displays much like the black swift. A display flight is initiated when one swift dashes at another. The two birds then chase each other until one escapes or until they fly off together. Rathbun stated, however, that "as it appears to be quite playful, these actions may be partly in sport, though at this particular time some must have an earnest intent, for the courtship of this little swift evidently takes place upon the wing" *(ibid.)*.

Aeronautes s. saxatalis

"Courtship" in our western, white-throated swift occurs largely on the wing, says Bent (1940: 311). He cites several valid observations of copulation in the air.

In Chaetura pelagica

Most descriptions of the chimney swift's display are brief and similar. They state that it is aerial, that the males chase the females, or simply that birds in small parties chase one another about (cf. Bendire, 1895: 178; Forbush, 1927: 312). As early as 1891 Kingston (p. 98) described trio flying—a conspicuous aspect of this bird's pair-formation behavior. Like that author, MacNamara

(1918: 40) assumed that the birds in a trio were two males pursuing a female.

Tyler, who wrote the section on the chimney swift in Bent (1940: 272-273) devoted a page to "courtship." Although a sketchy outline, it does elaborate on flight displays.

Commencement and weather influence

Display begins within two weeks after the swifts return to the breeding area. At first it occurs during the warmer part of the day and the influence of the weather is unmistakable. (Later it happens at any time.) In central New York this early display period extends from approximately April 25 to about May 15.

I spent the seasonally backward month of May 1952 in the study area investigating this aspect of chimney swift breeding biology. Display usually occurred between mid-morning and sunset. May 20, which followed three fine spring days, was an excellent example of the weather's impact. Previously, swifts had been displaying actively at Tract B. With the rain, wind and cold of the 20th, I was unable to detect a single bird in 2½ hours of observation. During early evening on the following day (also cold and rainy) I again failed to see any swifts there. When good weather returned on May 22, display began anew.

May 26 was another illustration. The weather that day was unsettled. Although display was in progress at Tract B, I noted that it was decidedly "dampened." When a storm threatened in the late afternoon, it ceased altogether.

In years of normal temperatures and seasonal development, aerial display reaches its peak soon after mid-May and extends to mid-June, and in this stage the weather exerts less influence. Early in spring, rain, cold or both are sufficient to halt it. Later, cold continues to have a strong effect, but a mere drizzle is not sufficient to drive the swifts to cover.

On several occasions during May 1952 I noticed that displaying birds ceased their activity in the face of imminent bad weather and, instead, joined the local swallows that were feeding avidly along the Beaver Kill. At such times, all species flew rapidly, erratically and close to the water's surface—their only concern seemed to be to gorge themselves with insects before the rain began.

Early display

During the first week or two after the swifts had returned for any particular summer, I frequently observed them flying in what

I have termed "loose association," in groups somewhat resembling a loose flock. While maintaining the loose flock organization the 4 to 7 individuals moved back and forth, often in a large circle, and appeared to be feeding. Subsequent study revealed that the birds were doing little or no feeding but were actually laying the foundations for the synchronized behavior which would insure breeding success later; away from the nest, the pair-bond was to be manifested in a distinctive kind of coordinated flying.

At times I saw birds detach themselves from such a group and fly together for several minutes. Then they rejoined the other swifts. On numerous occasions I observed just two swifts flying about a tract. They flew leisurely, within 200 feet of the ground, and chippered now and then. It was always evident that there was some attraction between them, because they did not drift further apart than a stone's throw. One followed the other, yet did not attempt to get ahead. This behavior I entered in my notes as "flying in association" or "flying together" (cf. Rathbun, 1925: 502).

Later display

This phase is marked by the conspicuous "trio flying" to which so many authors have referred and about which numerous colleagues have inquired. I admit my inability to state with certainty when early display ceases and this begins, and I am not certain there really are these separate phases. But trio flying remains a fascinating reality.

Trio flying has several characteristics. Often the three individuals seem to be playing a game of follow-the-leader as they thread their way among buildings and trees. Their incessant calling—louder than normal—is the familiar chipper broken up into single notes and it denotes excitement. Always, at least one bird's chips possess a sharp overtone which gives them a quality not heard at other times. It sounds like a chip and a whistle superimposed.

When display reaches peak intensity trio flying attains its highest pitch. The birds fly at speeds which more than justify their being called swifts. Whereas they formerly flew low and within several hundred yards of the nest site, now they regularly ascend to heights of more than 500 feet and a flight, in horizontal direction, takes them out of the range of seven-power binoculars. Also at this time a characteristic spacing becomes more evident than it was: the two "followers" are usually separated by a distance

just half that between the "leader" and the next in line. As the rapidly chipping birds race across the sky, they bear a striking resemblance to figure skaters. Sudden, angular turns are executed in unison. As a flight grows faster, the followers even up the distance between themselves and the leader. I do not know the maximum duration of these trio flights, although I have known them to last longer than five minutes.

To this outline of trio flying I shall now add what details are at hand. There is no doubt in my mind that the apparent follow-the-leader activity actually represents two males pursuing a female, as many persons have assumed. Males probably recognize females by some behavioral trait or traits, since the sexes appear similar to the human eye. Indirect evidence that swifts do possess sexual discrimination is afforded by the observation of Dixon (in Bent, 1940: 312) who made a special effort to collect white-rumped swifts' eggs in California. He wrote: "The females were in the nests the better part of the time, and the minute a female left a nest every male within sight would take after her."

In May 1952 I color-marked number 615 (known to be a female) and her presumed mate, number 627. On May 27 I watched 627 and an unmarked swift chasing 615. However, after this incident I saw 615 and an unmarked bird pursue 627 without interruption for five minutes. Possibly 627 was not a male. The bird soon disappeared, so I did not positively establish its sex.

Although a chase, it is one in which the pursuers must "catch" the pursued repeatedly. At one time in these studies of swift biology, I thought the pursuers incapable of catching the lead bird. This was incorrect. As the trio makes a turn, a follower can overtake the female by taking the inside of the turn and accelerating. Oddly, the new leader maintains its new position briefly. It often seemed that the new leader deliberately permitted the female to regain her former place. At other times I saw the female recover leadership merely by breaking away from the males and establishing a new course. The males followed her—which made them pursuers again.

There is definite competition between the pursuers for the position immediately behind the leader. Indeed, the pursuers' actions suggest that they are more concerned with achieving and holding second place than they are with overtaking the lead bird.

Long a source of wonder was my failure to observe physical strife between the followers. I did not witness it until June 1, 1953. On that evening I was studying trio flying on the Cornell

campus. As the swifts were quartering away from me, I saw the last bird overtake the middle one from above and grasp some of its back feathers. The two individuals continued to move forward rapidly yet they did not tumble or scramble. During contact, which lasted not more than three seconds, they lost altitude, making an angle of about 10 degrees off their previously level course. When contact was broken the two swifts separated widely, but in moments they were again in line chasing the leader. Since this was the only attack I witnessed during hundreds of observations, I do not think it is a common occurrence.

Earlier I alluded to the sharp overtone audible during trio flying. "Sharp chipping," as I call it, is an activity which I still do not understand fully. One inescapable conclusion was that I heard it less often when two birds were flying together than when a third swift appeared nearby. It seemed always to be *one* of the duet that gave the calls, and they indicated sexual excitement. However, two things made their precise meaning obscure.

I thought at first that sharp chipping might be given only by females, for on most occasions it was the leader in a duet or trio flight that emitted such sounds. Later I recorded instances which seemed to rule that out. Once I noted that a pursuer, giving sharp chips, overtook the leader. Another time three birds flew over me and two of them (one being the leader) were chipping sharply. One day when I watched two swifts flying together I wrote in my notes that the same individual was usually the leader and silent while the follower gave out a steady *chip-chip-chip . . .* that often rose to "sharp chipping." More work with color-marked birds of known sex could clarify this matter.

Throughout aerial display there occurs a unique flight trait that I call V-ing. Audubon (1840: 165) alluded to it more than a hundred years ago. Later, Sutton (1928: 87) partially described it. In the illustration accompanying Pearson's brief account (1911: 115-118) of the swift, Sawyer painted two birds engaging in V-ing. They were small silhouettes and adjuncts to the main painting, however. The cover drawing of this Bulletin, by William C. Dilger, also shows this display.

The performance is easily recognized. As two swifts sail by, chippering loudly and rapidly, the rear bird suddenly raises its wings so they form an acute angle with one another. The lead bird may or may not V also. At close range, an observer can see that the birds do not gently elevate their wings, but snap them into and out of the V position.

V-ing begins with the onset of display. It occurs less frequently in the beginning than later, and at first it is done by only one bird when two are flying together, or by not more than two during trio flying. It does not take place on a windy day, or when a trio is engaged in a heated chase.

If a person were to confine his observations to the time before pair-formation, he might conclude that V-ing is a display phenomenon used for that purpose only. Actually, it is used later also —well into autumn.

There are noteworthy oddities about V-ing. It is initiated (always, in my experience) by the rear bird or birds. When two swifts are flying during early display, the follower will raise its wings for a moment, then drop them down and resume flapping. Later in the season—when pair formation has taken place—the performance is most attractive. At intervals during their flying together the swifts will come within one foot of each other and commence to glide. The rear individual elevates its wings. Then the leader, who is always from 3 to 8 inches lower, raises its wings and the two noisy birds continue to glide in a graceful, downward curve. Again the resemblance to figure skaters is strong. Suddenly the follower snaps its wings back into normal sailing position and the leader momentarily follows suit. The V-ing performance ends, and seconds later the two are flapping normally and continue their flying in association.

V-ing not only exemplifies well coordinated muscular activity, but it also suggests highly integrated mental processes. For that reason it is seen at its best in a mated pair. In my study of courtship I never saw the lead bird initiate the act. Always it was the follower despite the fact that often they were oriented in a way that appeared to me to preclude the leader's seeing the follower. Yet with mated birds the leader could be counted on to raise its wings when the other did regardless of the follower's location.

There is no doubt in my mind that this highly coordinated flying—V-ing—is an outward expression of the physiological synchronization that makes successful breeding possible for chimney swifts. Since mated birds regularly engage in coordinated flying in the evening of a pleasant day (when the young are well fed) I believe this activity is necessary to maintain the sexual bond.

Although I did not commonly witness them, there were instances in which an "odd" swift attempted to disrupt the association flying of two others. At Tract B on May 28, 1952, two chimney swifts

that were about 12 inches apart and in good coordinated flight were abruptly separated by a third one that zoomed between them. On June 7, 1952, a bird at Tract C tried repeatedly to penetrate the relationship between the mated pair. There was no physical contact, but sharp chipping commenced when the third swift appeared and the ensuing trio flying was short lived.

Curtailed display

The behavior of the Tract C swifts—a pair which had returned for its third nesting—was illuminating during the 1952 period. I observed the birds regularly through the beginning of nest-building, yet I witnessed only mild display activity. Once I saw them flying in association, just after their return to the Tract. On most visits the birds were not present, so it is possible (though not probable) that they displayed elsewhere. The Nethersole-Thompsons (1943: 72) found that site-selection behavior may be drastically curtailed when a pair of common swifts uses the same nest site annually. If this can be applied to the chimney swift, it would explain the reduced amount of display which I noted.

Nest site inspection

During the 1952 courtship investigations in the study area I made several observations of site inspection. On the evening of May 4 I saw a lone chimney swift make a "feint" at the west peak of the smaller barn at Tract B. I was unable to understand such behavior in view of the fact that the peak offered no place for a nest. Five minutes later, however, presumably the same swift returned with a companion. While one seemed to be the leader, the other did the calling. Between 7:40 p.m. and 7:50 p.m. they made, together, three or four feints at the southwest window but did not enter. That night a single bird roosted on the west wall—the 1951 nest site. I did not disturb it.

At almost the same time the following evening I watched two swifts enter the barn at least five times. They stayed several minutes on each visit, then emerged to resume display flight. After dark I discovered them (presumably) roosting in the building. They were not side by side as I had expected; instead, one bird was clinging to a roof timber about one foot from the other in a manner so abnormal that I had no doubt it would change position before settling down for the night. Had I entered later than I did, I doubtless would have found the birds roosting in contact. They proved to be number 668 (which returned to the barn each year since its first nesting in 1949) and an unbanded swift.

In 1952 the Tract C swifts returned on May 18 or 19. On the 23d, at 2:10 p.m. (20 minutes after my arrival there) two birds appeared and flew in association for six minutes. At 2:16 p.m. one of them darted into the barn, followed in one minute by the other. Two minutes later I was in the building watching them. The birds were clinging to the hooked rug, above the dummy nest I had attached as a "lure" and were approximately 20 inches apart. At 2:26 p.m. one of the swifts commenced a soft, rhythmical chipping, then took a new position on the rug. During their stay both birds alternately preened and gazed about. At 2:40 p.m. one began to chipper softly and a few moments later flew out. One minute later, the second swift gave the standard chipper and departed. Though I remained at the Tract until 6:15 p.m., I did not see them again.

Copulation

Published observations of copulation in the family Apodidae are few indeed. It was seen in the common swift by Cutcliffe (1951: 48) who wrote only that: "Coition was witnessed on a few occasions at the nesting site, the female clinging vertically to a beam."

The Lacks (1952: 197) described their observations of the common swift thus:

> We not infrequently saw copulation in the (nest) boxes, but only between 0630 and 0730 and between 1630 and 1830 hours, these being the times of day when swifts seem most excited, both in their boxes and round the Tower. A characteristic subdued call, between a scream and a cluck, usually but not invariably preceded copulation. The female sat in the normal resting position on the floor of the box. The male then mounted, gripping the female's back with his claws and her nape with his beak. The female elevated the tail and the male twisted around, on one occasion almost lying on his back in the effort. Usually the male mounted three or four times in succession, but sometimes only once. Afterwards, there was usually mutual preening, but clucking was not heard. Copulation was observed only just prior to, and during, the egg-laying period.

Moreau (1942: 33) reported that one of his observers saw white-rumped swifts copulate. He says of the incident:

> At 09.12 two old birds went into the nest, and at once reappeared and fell struggling together to the ground. The observer opened the door to see what was happening and noted that he found them in copulation at his feet, one gripping the other by the nape feathers. They were so occupied that they did

not at once take flight, but remained in this position for about a minute.

The white-throated swift is the only American species whose copulation is described in the literature. Dawson (1923: 970) wrote:

> . . . the birds come together [in the air] from opposite directions, engage with the axes of their bodies held at a decided angle laterally, and begin to tumble slowly downward, turning over and over the while for several seconds, or until earth impends, whereupon they separate without further ado.

Michael (1926: 109) wrote:

> White-throated swifts we have seen cling together and pinwheel down through the air for a distance of five hundred feet.

Bent (1940: 311) supported his own statement that "coition may take place in the nesting crevice also" only with this note from Dixon:

> The males are so amative that when we would take the females out of the cracks they would pounce onto them while in our hands; and we actually caught a pair in this way . . .

For many years it was the opinion of ornithologists that our chimney swift copulated while in flight. Sutton (1928) ended his short description of courtship flight with this guarded statement: "It may be that this graceful and interesting display is at the culmination of courtship activity."

Some 11 years later, when he was writing the section on the chimney swift for Bent's *Life Histories* (1940), Tyler described a supposed copulation: "as the pursuer overtakes his goal, he rises a little above her and lifts up his wings, and there appears to be a moment of contact" (p. 273). He then cited Sutton's earlier description, saying that "the probability that the nuptial flight leads, at least sometimes, to sexual contact in the air is increased by Sutton's (1928) careful study of the swift."

A footnote in Bagg and Eliot (1937: 319) included the sentence: "Copulation was noted by Mr. Eliot on June 21, 1937." Since this would have constituted the first published observation of actual coition, I wrote Mr. Eliot for detailed information. He replied that the footnote was apropos of a second or mid-summer nesting and was based on an entry in his journal which read: "Swifts mated in air." Mr. Eliot kindly added that he thought he had "seen more than once, since, the same momentary contact, accompanied by slower or hesitant flight, as 2 swifts fly close together. Whether sperm actually is injected, who could say? It stands to reason

they must mate in flight, for when at rest must they not press their tails close to the wall?" I do not believe that Mr. Eliot saw copulation.

Dexter (1950: 101) in a paper on this species stated "Copulation was observed when the nest was one-half completed." In amplification of this statement, Professor Dexter wrote me that he saw a pair copulate near their nest while he shined a light down their chimney after dark; that is, one bird was on top of the other when he looked down at them. He made a similar observation in 1955, but in view of my description of the act (see below) Dr. Dexter does not rigorously maintain that he saw actual coition. Yet, he is at a loss to explain the meaning of his observations.

During many years of observing breeding chimney swifts I witnessed a single incident of a kind that could lead to the conclusion that the species copulates on the wing. On May 28, 1952, chimney swifts were displaying vigorously at Tract A. Five birds flew in loose association; occasionally it was four, but most often there were only three. All five engaged in V-ing. As two birds glided with wings in the V position (the follower about 8 inches behind and 3 inches above the leader) the follower, without moving its wings in any way, appeared to thrust its body at the leader and make momentary contact in the position perhaps suitable for coition. The lead bird was not visibly jarred by the collision, but immediately both birds ceased V-ing and separated.

Many times I wondered about the observation. Now, I believe the contact was apparent and was caused by my position with respect to the birds. During V-ing the follower often catches up to the lead bird as a result of skillful gliding or greater momentum when it began the V-ing performance. At such times the birds are so close that it would seem their wings must become tangled. Should this occur when birds and observer are properly oriented, the person would think he saw deliberate body contact. If the chimney swift copulated in the air, there should be, by this time, descriptions in the literature of the falling leaf or aerial scramble type of union that was reported for the white-throated swift by Dawson (see above). But in view of the paucity of observations of aerial copulation among larger species of swifts, we cannot insist that it does not occur in the chimney swift.

When finally I did witness actual copulation at a nest site, the idea of aerial copulation became more difficult to accept. The preliminaries, the act itself and the subsequent behavior were

so highly stereotyped that an alternative, aerial method seems to me an impossible idea.

Since my 1952 observations of chimney swift copulation are the first to be placed on record, I shall relate them fully.

The Tract C swifts began nest-building on May 28 or early on May 29. On the afternoon of the latter date I counted a dozen sticks fastened to various places on the rug; six of them were stuck together and subsequently became the nest's foundation. (A detailed account of nest building will be given later.) On June 7 the nest appeared to be half-finished. The weather that day was good, and display flying was generally in evidence at mid-day.

I was at the Tract from 1:24 until 7:35 p.m. to watch nest-building. At 3:39, while standing at the barn door observing display flying, I suddenly heard chippering upstairs. Both swifts had entered; one was at the nest, the other clung to the rug, a Y-shaped stick crossways in its bill. After preening and adding saliva to the nest, the "nest" bird got off at 3:49 whereupon the "stick" bird immediately fluttered on and attached the twig. It added some saliva to various parts of the nest and flew off four minutes later. Both swifts preened until 3:56, at which time the "stick" bird crawled to a point just below and to the left of the other. At 4 p.m. the "stick" bird began a series of undulating chippers which ended while he crawled and gently fluttered up onto the other swift's back. The copulatory position was maintained for approximately two seconds. The male flew off his mate's back, landing near the nest. In a moment he fluttered on to the nest and added more saliva to it. Meanwhile, his mate alternately preened and "dozed." The male fluttered down near the female at 4:05 and both preened.

At 4:10 the female delicately fluttered down alongside the male, but in a moment he fluttered away (to his left). She moved over again, but again he retreated. The female went back on the nest at 4:13 and added saliva. At 4:17, without the usual preliminary chipper, the male flew quietly out of the building. After getting off the nest at 4:19, the female began soft, short, rhythmical chipping and departed half a minute later.

When I had to leave the site at 7:35, a bird had just completed a nest-building period.

June 8 was another good weather day and I spent 6½ hours at Tract C. Like the preceding day display flying (which this time involved an animated trio) ceased abruptly when a swift entered

the barn at 1:20 to continue nest-building. At 3:07 the other (?) bird added a stick.

I was absent from 3:30 to 4:35. On my return, both swifts were on the rug preening; evidently they had just done more work on the nest. At 4:44 one individual fluttered up next to the other and both preened occasionally. Until they departed at 4:56, the swifts looked exactly like roosting birds. In many observations of nest relief, extending over 10 years, I had not seen mated birds behave that way. At 4:56 one of them barely started the soft, accelerated chipping, then gave the familiar chipper and departed. Moments later the mate chippered and flew out. Within one minute I heard display flying outside, though it lasted only three minutes.

No birds had come in again by 6:20. I chanced to look through a knothole in the barn and saw two swifts flying in association. They were gone five minutes afterwards. At 6:30 I risked a climb to the nest and discovered the first egg. (The nest was empty earlier at 1 p.m.)

While downstairs getting the camera ready, I heard chippering at the nest; both swifts were on the rug. (The time was 6:40.) One, which turned out to be the female, had a twig. The male had none, so I surmised he had merely followed his mate into the site. The female fastened her stick to the nest at 6:45 and, having added some saliva, got off at 6:47. Both swifts then preened.

At 6:51 the male fluttered to a point just below and to the left of his mate, his head on a line with her rump. Though the female continued to preen actively, the mate was unusually still. Four minutes later, the male gave the undulating series of chippers (which I deciphered as three standard calls strung together), at the same time crawling up on his mate's left side and establishing cloacal contact. I watched the birds through seven-power binoculars but because of the dimness and short, three-second duration of the act, I could not be certain whether the female twisted her body or raised her tail. Immediately on conclusion of copulation the male flew off her and got on the nest. He merely sat there.

The male swift flew down to the female's left side at 6:59. Three times during the following few minutes she fluttered down and over to him and attempted to get her body against his, but each time he moved away immediately (always in the direction of the nest). On her last attempt he flew around to her right side, leaving her next to the nest. She got on almost immediately though

she apparently did no work on the nest during her four-minute stay. On fluttering off, the female landed about six inches above and to the right of the mate. Then she preened frequently, he occasionally.

At 7:10 the male fluttered and crept gently up to his mate, which put him in the same position I noted at 6:51. Again he became very still, not turning his head from straight ahead even when the female brushed him with her wing tips during preening. But during her activity, either she backed down a bit or he crawled imperceptibly upward, for soon his head was nearly hidden under her left wing.

The undulating series of chippers commenced at 7:12 as the male crawled and fluttered gently across his mate's rump and through the binoculars I clearly saw her twist her body toward his cloaca. Their union lasted between three and four seconds—longer than the two previous acts. As at 6:54, the male flew off the female and landed close to the nest. He fluttered to it immediately and got on. Again he merely sat on the nest until getting off at 7:15.

The male gave a soft, standard chipper at 7:18 and departed quietly. A moment after, the female chippered with normal volume and flew out. Nest-building ceased at 8:35, when the birds were in for the night.

On June 9 I was at the barn from 10:40 a.m. until 1:12 p.m., from 1:25 to 1:30 and from 2:25 until 6:35 p.m. No eggs were deposited. Considering the good weather and the birds' continued nest-building, I was surprised not to witness copulation.

There was a second egg in the nest when I examined it at 8:40 a.m. on June 10. Between 11:50 a.m. and 1:40 p.m. I observed copulation for the fourth and last time. At 12:54 a swift entered silently with a twig. Two minutes after, the other came in with one. By this time I was able to differentiate between the sexes since I had noticed that the male's rump and tips of the primaries were lighter than his back, wing coverts and rest of the primaries.

The male fastened his twig to the nest at 12:59, added some saliva to different places, and lingered in an incubating position until 1:15. Meanwhile, the female, who had dropped her stick, preened vigorously.

At 1:07 the male had apparently entered into the stage preliminary to copulation, for he was very still. During the ensuing five minutes he preened one wing once. The female continued to

preen less actively, and I detected that she was slowly working her way down to the male. By 1:09 her wing tips were touching his. At 1:10 the female deliberately backed down and lined up her body so close to the male's that without binoculars I should have thought only one swift was on the rug. Her tail spines were partly on his back, partly on the rug.

They copulated at 1:12. Accompanied by the now characteristic series of three chippers, the male crawled onto the female, and arched his back so the tail was nearly horizontal (pointed toward the rug) while the female twisted the lower part of her body toward his. I saw him grip her rump feathers with his left leg. After two seconds of contact he flew off and went directly to the nest and got on. As before, the male just sat on the nest (for 3½ minutes) in incubating position. At times he closed his eyes briefly. In the meantime, the female dozed a good deal; occasionally she preened. At 1:15½ the male chippered, flew off the nest, and alighted on the rug. He departed half a minute later. One minute after that, the female chippered softly two times and flew out.

Certain parallelisms between the copulatory behavior of the European common swift (as the Lacks described it) and our chimney swift are obvious.

With both species, copulation occurred while the females were in normal resting positions. A characteristic call preceded the acts, though in our swift it was not at all subdued. I did not see the male chimney swift grip his mate's nape feathers (as the Lacks did with their birds) and I feel sure it did not happen. However, males of both species gripped the females' rumps, and in each case the females were seen to twist their bodies. Preening (which with the Lacks was the characteristic mutual preening of courtship) followed copulation. But to me the most interesting similarity was the fact that for both species, copulation occurred in the short period embracing egg-laying. Finally I knew why I had not seen copulation during the hundreds of hours I studied incubation.

NEST-BUILDING AND EGG-LAYING

Unlike display and copulation, the chimney swift's nest-building and egg-laying have been studied and described by several ornithologists. My own investigations of these aspects of swift biology were incomplete because of my inability to be in the study area at the beginning of nesting, except in May 1952.

A careful reading of the literature on nest-building disclosed that few of those who published on it had actually observed the process. Widmann (1922: 56) had good opportunities to observe nest-building in his artificial chimney and he gave a generally good description of the nest and saliva. Yet, he seems to have made certain misstatements which I shall discuss in their turn. Miss Sherman (1952: 40-61) made careful observations of swifts in her artificial chimney and her data are unassailable. MacNamara (1918: 40) and Reed (1901: 193), to name only two, evidently read the writings of others before preparing their accounts. Some of their statements are evidently based on misinformation or incorrect inferences. More recently, Professor Dexter has compiled material (published and unpublished) that is both unique and reliable.

Materials and their seizure

A chimney swift is silent when gathering nesting material. The bird flies in a large circle around a dead tree or the dead tips of branches. As it approaches the desired twig, the bird usually rises up to it a trifle and, fluttering there for not longer than one second, attempts to snap the stick off, usually with both feet. The swift's momentum is the breaking force. At a distance greater than 100 feet, the act looks like a continuous movement with a barely perceptible pause at the moment of contact with the twig. At that distance I would not expect an observer to be able to state with certainty whether the feet or bill is used. The bird makes repeated attempts at the same or a nearby stick until it is successful.

When Louis Agassiz Fuertes portrayed a chimney swift seizing a twig in its feet, he touched off a brief controversy over the correctness of his representation. (The painting is reproduced in Coues' *Key to North American Birds*, 5th edition, 1927, vol. 2, p. 559.) Dr. Coues believed the bird grasped a twig only in its bill; hence, he queried ornithologists for their opinions. Five readers of *The Nidologist* held Coues' view while one agreed with the artist. A seventh reply, in accord with Fuertes, appeared in *The Osprey* (Bent, 1940: 281). Bendire (1895: 182) said the swift breaks twigs off with its bill.

Shelley (1927: 116), who watched chimney swifts obtain sticks for 13 consecutive summers, maintained that the birds used only their feet. I have witnessed it frequently, and always the swifts snapped the twigs off with their feet. Professor Arthur A. Allen and Dr. Robert Cushman Murphy have seen birds obtain sticks

with their bills as well as with their feet. At such times, the birds must have taken very slender twigs—an uncommon occurrence in my experience. Most twigs in a nest average three millimeters in thickness and are too thick and resistant to have been broken off by the swift's small, soft bill.

Apparently few persons have seen the chimney swift gather nest material. Hence, in the general accounts of the species found in many bird books we often read the indefinite statement "the birds snap the twigs off while in flight" (cf. Weed and Dearborn, 1916: 178).

MacNamara (1918) had seen the swift obtain sticks with its feet. Before he wrote a brief, general account of the species he had evidently studied the Fuertes painting, in which the bird looks as though it had dropped down upon the twig in its feet. So, MacNamara wrote: "Hovering a moment over a dead and brittle branch, it drops with elevated wings and, grasping at a dry twig with its claws, breaks it off and flies away with it."

Chimney swifts use whatever twigs are available. I have seen them take twigs from the basswood *(Tilia americana),* apple (*Pyrus sp.*), black locust (*Robinia pseudo-acacia*) and red maple *(Acer rubrum).* In the study area, sugar maple *(Acer nigrum)* was a dominant tree and all the nests contained a preponderance of its twigs. (They can be recognized in many of the photographs.) Examination showed that most of the heavier sticks had broken off at the terminal bud scars.

Regardless of how the chimney swift gets a stick, it arrives at the nest site with the twig in its bill. Brewster (1937: 189) saw a bird enter his chimney with a twig held crossways in the bill, and Miss Sherman (1952) must have seen this behavior during her extensive nest-building observations. I have never seen a swift arrive at its nest with a stick in its feet, but Widmann wrote: "These twigs . . . are carried to the nest with their feet" (1922: 56). However, a perusal of all his writings on the species failed to locate a single statement to the effect that he saw a swift arrive at its nest with a twig in its feet. One could expect that to happen if the bird were in the habit of flying directly to the nest. In 14 years of intimate observations, I noted that the only time a bird has flown directly to its nest—which was decidedly atypical —was to feed the young. But nest-building had ended long before.

The nest

The 1952 Tract C chimney swifts began to build a nest late on May 28 or early on May 29. They chose a location on the rug three

inches above and to the right of the place on which they had been roosting since May 21.

At the time I discovered the "nest" on May 29, the birds had typically attached three separate sticks to the rug a little to the left of the main cluster of nine. These first three sticks probably represented "test" locations. In previous years they (or other swifts) had made many tests as reference to any of the 1951 nest photographs will show. Although this was the first nest I had observed from the start, I had seen many that were being finished or had just been completed.

Widmann's statement (1922: 56) that the chimney swift starts construction by first smearing "a good layer of glue against the wall" and attaching a few short twigs to it while still wet is so at variance with my experiences that I doubt its accuracy. Invariably, one sees a thick, yellowish layer of saliva that forms a semicircle on the wall above a swift's nest. (Years after a barn nest has fallen down, the location of the old semicircle is still evident because its tone is lighter than the rest of the wood.) Widmann apparently noticed it, too, and I fear he based his statement on what he *thought* rather than on what he *saw*. It is not until incubation begins that the saliva semicircle is laid down, and it is done by the birds as they sit on the eggs. The progressive addition of saliva to form a semicircle is well illustrated in the series of photographs which depict construction of the 1952 Tract C nest. The semicircle was shown in Audubon's (1840: facing p. 164) painting of a nest more than 100 years ago.

Sectioned from front to back, a chimney swift's nest is roughly the shape of a right-angle triangle; the part of the nest fastened to the wall represents the triangle's base. The greatest strain on a nest of this sort is at the points where the upper, rear portions meet the wall. This is precisely the region which the swifts strengthen when they add the semicircle of saliva. In view of the long period of nest life, it is interesting that there has evolved this time-saving habit of adding the reinforcement after the nest supports the incubating birds, but before the heavier strain of squirming, growing young is placed on it.

Nest-building is apparently restricted to the afternoon and early evening. My observations of it all occurred at that time, and Sherman (1952) and Widmann (*in* Bendire, 1895: 178) had the same experience. In addition, I have never seen twig-gathering in the morning. Widmann felt that swifts did not build in the morning because the atmosphere was still saturated with moisture and

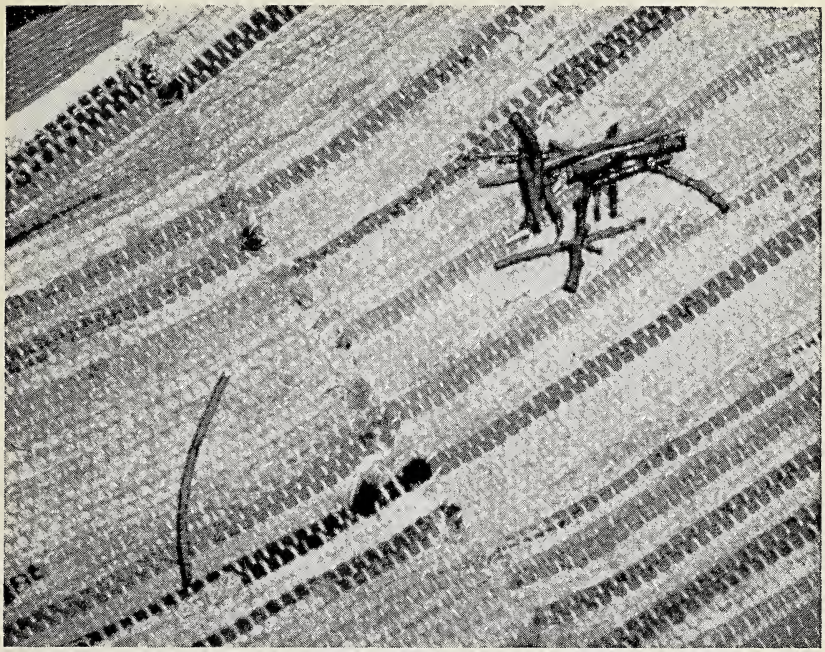


Figure 3. Beginning of the 1952 Tract C nest, built on almost the same spot the birds had used for roosting. Note the "test" stick at the lower left. Photographed May 30, 1952.

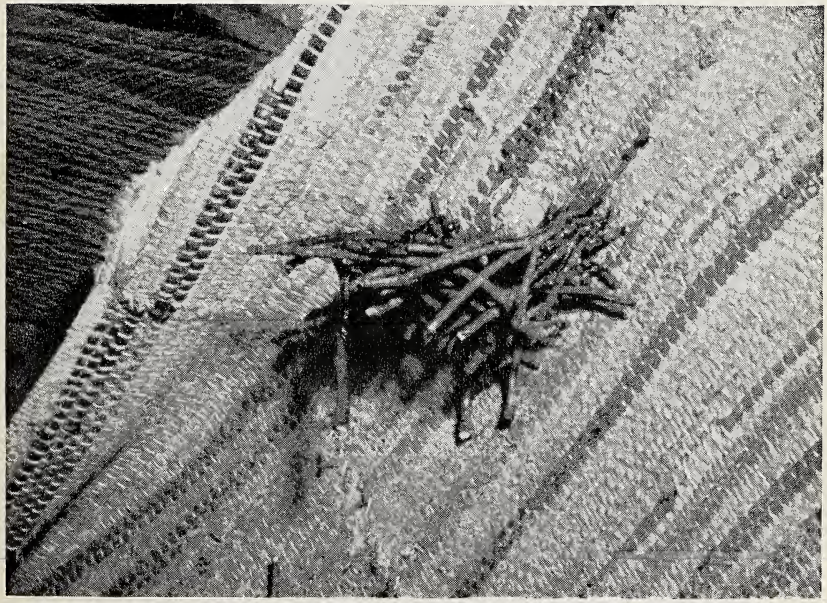


Figure 4. The same nest one week later. Photographed June 6, 1952.

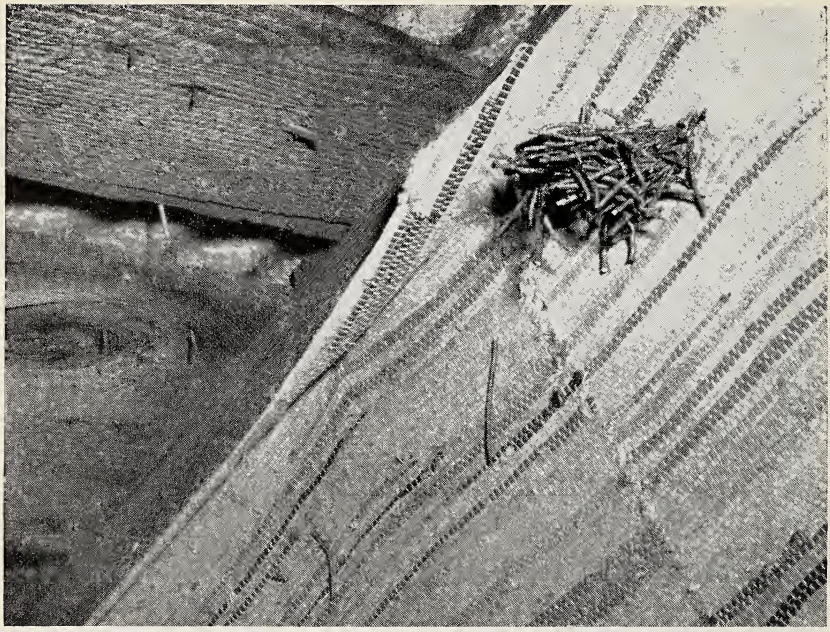


Figure 5. The same nest 15 days later, half finished, now contains four eggs. Photographed June 14, 1952.

Figure 6. The nest now holds the full set of five eggs and the incubating adults have commenced the semicircle of saliva, which looks like a stain above right-hand end of nest. Nest-building continues until hatching occurs. Photographed June 21, 1952.

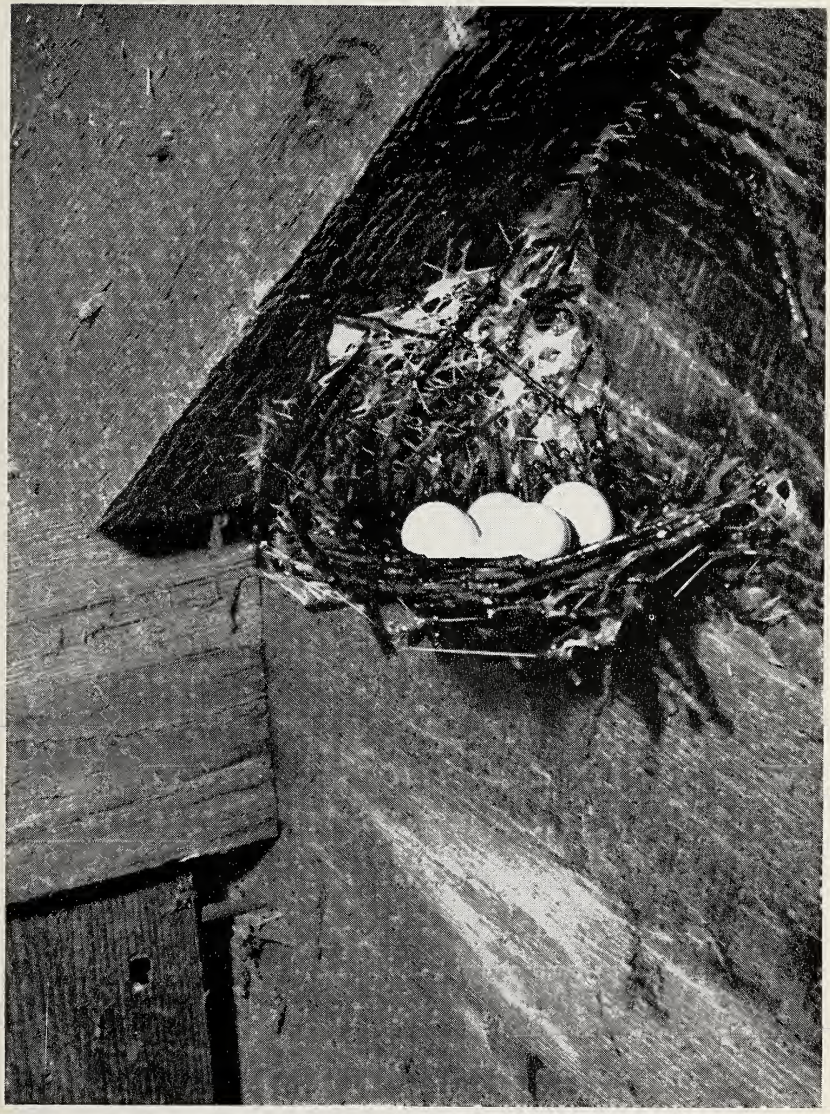


Figure 7. The chimney swift's typical stick-and-saliva nest (Tract A, 1953). Sets of 4 and 5 eggs were equally common in the study area. The incubation period varied from 19 to 21 days. Hatching success was 90.7 percent. Photographed July 2, 1953.

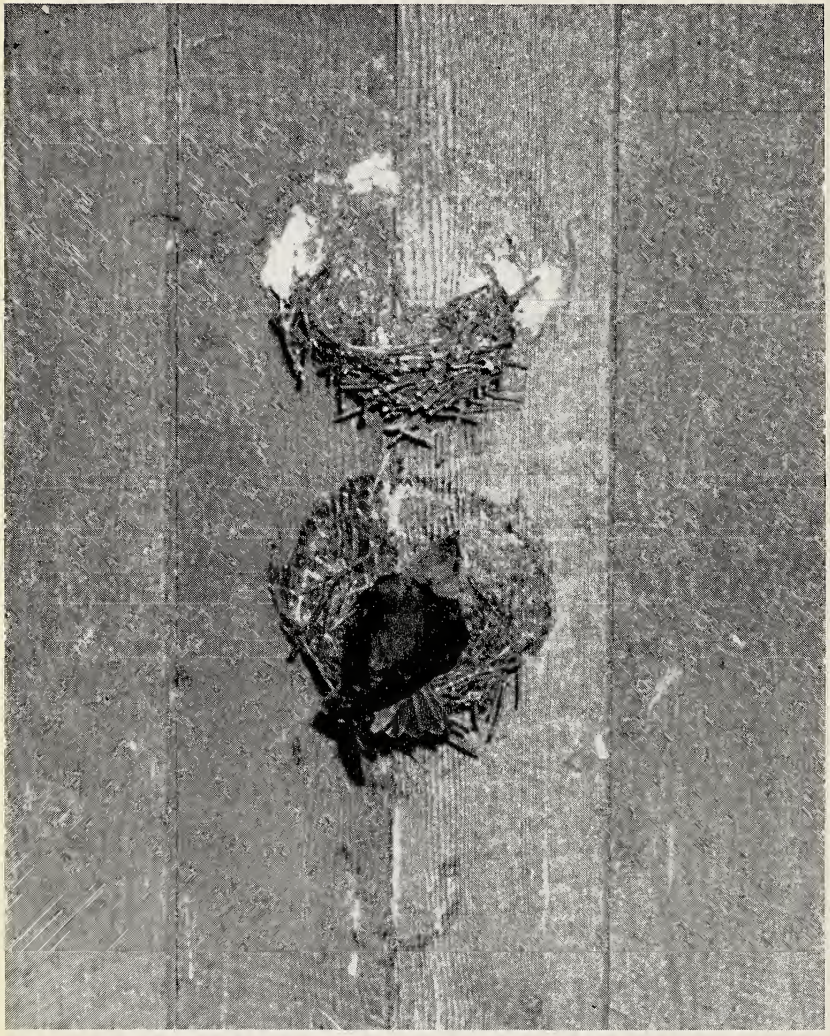


Figure 8. An adult chimney swift in typical incubating position on the 1947 Tract A silo nest. While sitting, the swifts add the saliva semicircle and additional saliva to the nest. It is noticeably smaller than the 1946 nest (upper) but the birds will continue to enlarge it until their eggs hatch. Length of attentive periods varied from 20 to 216 minutes. Photographed July 6, 1947.

the birds' glue would not dry quickly enough (*in* Bendire, 1895: 178-179). For the same reason, said Widmann, building seldom takes place during rainy weather. My experience bore him out; however, on June 2, 1937, Miss Sherman noted construction when there was rain and the thermometer stood at 51 degrees F.

A considerable amount of nest-building was necessarily described in the section on courtship (under copulation); hence, I need offer little more here. As I indicated earlier, both sexes independently build the nest. This is also true of *Apus a. apus* (Lack, 1952: 197). From the time there were only 10 sticks in the 1952 Tract C nest, the birds clung to the cluster when they added more twigs and saliva. Sometimes the swifts contorted their bodies in ways that resembled passerines when they shape their nests. After the nest was large enough for the swifts to get onto it, they did all their work while they sat on it even though, to human eyes, the position seemed awkward.

Baerg (1951: 85) stated that "a study of nesting habits has been made by an ornithology student (Louise Bell)." Then he presents what appears to be a condensation of her notes. Included is the remark:

> While working, the birds hold a small bundle of sticks against the wall by means of the stiff tail feathers. One by one the sticks are taken up, covered with saliva, and put into place.

This statement is unique in the literature concerning the chimney swift!

Professor Dexter's papers (cf. 1950: 100 and 101) often contain a statement such as "they tore the old nest off the wall as soon as they return in the spring." Although it is true that old nests are often broken off their supports, these seemingly deliberate actions are actually the incidental results of their habit of building while crouched or clinging on the nest. Chimney swifts regularly reuse their nests and in my experience they always added some new sticks. Amadon (1936: 216) and Miss Sherman (1952: 42) also noted this. The species' characteristic nest-building behavior therefore results in the destruction of unsafe nests, and the chances for successful breeding are increased.

Fresh saliva has the appearance and viscosity of glycerine. When fully dry it is pale yellow, translucent and astonishingly strong. No one knows exactly how long it takes to dry, so two of my observations are pertinent. On June 29, 1950, I saw a Tract F swift add a stick to its nest at 12:57 p.m. By 1:23 the saliva was still soft but had the consistency of thick glue. I waited until 3:43 for an

incubating bird to leave the site before I examined the twig again. The "glue" had set. The weather was overcast from 1 p.m. on, and sprinkles of rain fell from 1:40 to 1:50, and from 4:10 to 4:15.

A twig that I found on the floor under the Tract C nest on May 29, 1952, had a soft spot of saliva on it at 4:05 p.m. It was dry and hard at 5:40. The day was warm, humid and overcast. If the saliva hardens by evaporation (rather than by some chemical change) then the weather may have prolonged drying in each case.

When the nest is about half finished, egg-laying begins. The birds continue to build during the laying period and cease adding sticks shortly before the eggs hatch. I found no evidence that nest-building occurred after hatching took place. (The Lacks (1952: 197-199) found that nest-building in the common swift proceeded in similar fashion.) Considering its long breeding cycle, "time saving" activities like this, the postponed addition of the saliva semicircle, and the reuse of previous years' nests must have considerable survival value for the chimney swift. Interesting would be a comparative study of reproductive success for chimney nesters versus those that occupy interiors of buildings. I believe the latter group to be more successful.

Dexter has written (1952: 290) that a nest is usually completed within 3 to 6 days, but he based his figures on the period from the start of nest-building to the laying of the first egg. (Since his birds nested in air shafts, he was apparently unable to see that eggs were deposited in a half-completed nest.) Widmann's figure of "about 18 days" to build a nest (*in* Bendire, 1895: 180) was probably an average time since construction of the 1952 Tract C nest went on for fully 30 days.

According to Dexter (1951c: 9 and 1952b: 8), it was not uncommon to find one or both adults roosting on the empty, unfinished nest at night. I recorded one instance in which a bird roosted on the foundation while the other was typically pressed against its mate.

Completed nests in the study area varied in inside depth from 2.5 to 3.1 cm. Their widths from left to right averaged 10 cm. The distance from front to back ranged between 5.0 and 7.5 cm. These measurements agreed with those of Miss Sherman (1952: 42) and Bendire (1895: 181). The shape is best described as half a saucer. Contrary to Reed's statement (1901: 193), they are not "lined with a few grasses." Possibly Reed got his idea from an old nest in a haymow, where some grass could have fallen into it.

Occasionally swifts build a nest that is not a half saucer. Bendire (1895: 181), in his excellent description of the nest, told of one in which "the outer edges, where attached to the wall, are carried completely around on the top, so that it can be hung upon a peg, like a small wall pocket. . ."

Dr. Ralph S. Palmer presented me with a nest taken by Mr. Ralph T. Waterman at Poughkeepsie, New York. A complete saucer, it was attached to the wall of a barn and was not built on a projecting timber.

Although it is only a basket of sticks and saliva, the chimney swift's nest is admirably suited to the needs of its young. The young swifts' feet are unusually well developed at hatching, and a twig nest offers many places to grip. When the nestlings defecate or receive food, there is danger that one might fall out of the nest. I have seen many young save themselves from death by grasping a twig that held fast until the bird pulled itself back into the nest. By the close of a nesting season, many sticks that projected beyond the general contour of the nest have been broken off by the parents and the active young.

Egg-laying

As stated earlier, egg-laying begins when the chimney swift's nest is approximately half finished. No eggs had been deposited in the Tract C nest up to the time I witnessed copulation on June 7, 1952. There was still no egg on June 8 at 1 p.m. At 3:09 I saw a swift get on the nest to add a stick, and the individual remained on it for seven minutes. I was obliged to leave the site at 3:30; on my return at 4:35, both swifts were clinging to the rug. They had departed by 4:56, and when I examined the nest it contained the first of their five eggs. Hence, egg-laying had taken place sometime between 3:09 and 4:35 p.m. Although not an observation of egg deposition, this constitutes the only instance in which the approximate time is known. Moore (1902: 162) said that "the eggs are laid usually in the morning, one being laid each day until the set is completed, the number being five." However, he was incorrect in stating that this swift lays each day and that the clutch is five, and since he offered no field notes in support of his remark I am inclined to discount it. The fact is, we do not know when the swift usually deposits its eggs.

This species normally does not deposit an egg each day. Instead, it usually lays every other day, as Amadon (1936: 216), Miss Sherman (1952: 43), and Dexter (1951c: 9) also noted. Dexter recorded

two instances (involving different females) in which three days elapsed between laying (1950: 104; 1952: 291). In the one instance of this sort that Miss Sherman reported, the female required 12 days to lay her six eggs. Evidently Widmann had observed this, also, for he wrote to Major Bendire that "the bird can control the laying of eggs; can discontinue for one or more days, if she thinks necessary" (Bendire, 1895: 180).

THE EGGS AND INCUBATION

Clutch size

In the study area I recorded 45 nestings and attempts to nest. For 25, I arrived early enough to count the number of eggs in the sets. Ten sets had 5 eggs, 10 had 4, 4 had 3, and 1 had 2 eggs. I did not find any sets of 6 eggs, and among the 38 broods none contained 6.

In 26 nests, Dexter (1950, 1951*b*, 1951*c*, 1952*a*, 1952*b*) reported that 4 held 5 eggs, 15 held 4, and 7 held 3 eggs. He found no 6-egg clutches though one nest had 7 eggs (personal communication). Bent (1940: 275) says 3 to 6 eggs, more commonly 4 or 5 comprise the set.

Miss Sherman (1952: 59), reporting on 19 consecutive nests in her artificial chimney, found 5 nests with 6 eggs, 11 with 5, 2 with 4, and 1 with 8 eggs. It might well be that sets greater than 6 involve laying by more than one female. In the case of Dexter's clutch of 7, 3 birds were attending the nest, and he suggests the odd bird might have been a female.

At this time the data are insufficient to state whether the chimney swift's clutch size in the United States differs in the North and South. Lack and Arn (1947) showed that the common swift has a larger average clutch size in Switzerland than in England.

Consecutive sets by the same female

In the few instances where I knew the previous year's female had returned, I obtained data on successive clutch sizes. The bird that laid 3 eggs at Tract G in 1948 deposited 5 in 1949. A female that bred at Tract B (in the smaller barn) had sets of 4 eggs in 1950 and 1951. The bird also nested there in 1949; I did not learn the clutch size, but at least 2 young hatched. The Tract F female deposited at least 3 eggs (and probably only 3) in 1949. In 1950 her set was again 3. At Tract C, the swift laid 4 eggs in 1950, 4 in 1951, and 5 in 1952.

Egg color, shape and size

Bent (1940: 275) describes the chimney swift's eggs as "pure white and only moderately glossy." To this I would add that the membrane separates from the shell a few days after hatching and seems tougher than the shell. "In shape they vary from elliptical-ovate to cylindrical-ovate," Bent continues. "The measurement of 56 eggs average 20.10 by 13.24 millimeters; the eggs showing the four extremes measure 21.59 by 13.46, 21.34 by 13.72, 17.53 by 13.72, and 18.29 by 12.70 millimeters."

Egg weight

The weight of the chimney swift's egg was unknown until I weighed several sets in 1950 through 1953. The 22 eggs yielded the data presented in table 13. The table is self-explanatory, but I might point out the weights fell within a range of only 0.3 grams.

TABLE 13
Weights of Chimney Swift Eggs

TRACT	YEAR	EGG 1	EGG 2	EGG 3	EGG 4	EGG 5	AVERAGE
A	1950	1.8	1.8	1.8	1.8		1.8
B	1950	1.9	1.8	1.9			1.9
F	1950	1.8	1.9				1.85
C	1950	1.8	1.8	1.8	1.9		1.8
C	1951	1.8	1.8	2.0	2.0		1.9
C*	1952	2.0	2.1	2.0	1.8	2.0	2.0
A†	1953	1.7	1.7	1.8	1.8		1.75

Eggs were numbered 1-5 merely to list them in the table.
Eggs were fresh, or less than ½ incubated.
* For this year only, eggs were weighed in the order deposited.
† Beginning to hatch, so not included in average egg weight.
Tract C eggs were all from the same female.
Average weight of the 22 fresh eggs: 1.88 grams.

Renesting

If something happens to the eggs early in the breeding cycle, the female will usually re-lay in the same nest, apparently within two weeks (Widmann, *in* Bendire, 1895: 180; Moore, 1902: 162). Dexter (1951: 45-46) told of two instances wherein nests with complete sets of eggs were washed off the walls by rains. The birds immediately rebuilt on the old foundations and brought off young successfully.

A nest was disturbed at Tract B in July 1943. The birds were incubating on July 8, but on July 12 their nest was empty. However, on July 27 2 eggs were in the nest, and a third was deposited a day or two later. When I left the study area on August 14, the nest still held 3 eggs and I assumed it had been deserted.

Renestings are doubtless the reason. Audubon (1840: 165), Wilson (1812: 49), Barrows (1912: 381) and others have stated that the species raises two broods per summer. As early as 1895, Widmann (*in* Bendire, 1895: 178) questioned this when he said

> It is stated that the swift makes two broods south of Pennsylvania. This is very improbable, since the successful rearing of a brood of swifts takes not less than two months, which is much longer than the authors who make the statement allow for the process.

Present-day ornithologists agree that the chimney swift is single-brooded, but Bagg and Eliot (1937: 319) take issue with Forbush (1927: 311) and, citing two old papers (Stearns, 1884; Clark, 1887) insist that it raises two broods a summer.

Effect of moving eggs

On July 3, 1950, I conducted a simple experiment to see what a pair of swifts would do if their eggs were moved. I flushed number 777 off the nest in the smaller barn at Tract B at 1:10 p.m. and placed all four eggs in an old nest that I had enlarged, strengthened and mounted on a board that I fastened 25 inches below the real nest.

At 1:27 number 668 entered, landed 10 inches below and to the left of its nest and chippered. One minute later the bird flew to the base of the nest, then fluttered across its front and got on. During the first four minutes on the empty nest, 668 fussed and fidgeted repeatedly; afterwards it calmed down some.

Number 668 chippered and flew off the nest at 1:35, landing 6 inches west by south. It flew to the base of the nest at 1:36, and chippered a minute after. At 1:38½ it chippered again. A ¼-minute later 668 chippered and quietly departed.

It was not until 3:37 that number 777 came in, landing two feet below and to the left of its nest. It chippered in half a minute. I watched the bird from a dark closet some 25 feet away and my head was partly exposed when 777 entered. I withdrew and doubt that the bird knew I was there. While on the nest wall, 777 looked to the right and left several times, but 1½ minutes after it had entered, the bird silently flew out. I surmised that this individual behaved this way because its mate was not on the nest waiting to be relieved. However, since 777 was the swift I had flushed at the beginning of the experiment, it is quite possible that it saw me in the closet at 3:37 and departed through fear.

When no swifts had returned by 4 p.m., I replaced the eggs in the real nest. Number 777 flew in at 4:25 and chippered as it

alighted 9 inches below the mounted nest. A few seconds later the swift flew to a point 7 inches above the dummy, but its nails missed their hold and the bird landed several inches lower, chippering as it came to rest. Then it flew to the base of its nest and fluttered across the front and onto the eggs at 4:27.75. In other words, 777 took three-quarters of a minute to get on the eggs. Number 777 displayed no "anxiety" while it incubated. It was still on when 668 came in at 5:12 and did not get off until its mate was already on the nest. Then it flew out immediately.

Effect of removing one egg

In order to learn how swifts would react to having their clutch reduced, I selected the pair at Tract F for experimentation. They had 3 eggs—their full clutch—on June 20; 2 of these probably would have hatched, but the third (actually the first to be deposited) had gotten cracked in some manner and it was stuck to the nest.

At 1:24 p.m. on June 29 I removed the cracked egg and also the second egg to be laid, and placed a cover over the window to prevent the birds from entering during my absence. The good egg was rushed over to Tract C a mile away and placed in the nest. By 1:40 I was back in Tract F waiting to see what would happen. Swift number 790 entered at 1:48, but during the 33 minutes it took to get onto its eggs the bird snapped its wings and gave ample evidence that it was disturbed. Incubation lasted from 2:05 to 2:45; however, after 2:30 the bird appeared fidgety, seeming to turn its single egg and its own position more often than usual. From 2:45 (when the bird had flown out) until my departure at 5:30 no swifts entered the nest site. The woodhouse in which these birds were nesting was visited at 9:40 p.m. and I was relieved to find number 789 on the nest and its mate on the wall.

I arrived at Tract F at 1:48 p.m. on June 30, when no birds were present. Chimney swift number 790 entered 7 minutes later and was on the nest in just 1 minute. At 2:33 and 2:36 it chippered once. The bird flew off the nest at 2:36½, snapping its wings and alighting 6 inches below even though I had been sitting silent and motionless behind a blind for some time. After this swift flew out at 2:39 no others entered up to 5:45, when I had to leave, but after dark it was roosting on the wall with its mate on the nest.

On July 1 number 790 was found on the eggs at 11:45 a.m.; at 9:40 p.m. its mate was again on the nest while it was close by. I photographed them in that position and was obliged to replace

number 799 on the wall because it had flushed. Number 790 was incubating at 3:38 p.m. on July 2 and I flushed it to see whether any more eggs had been laid; none had. Unfortunately, I was unable to visit the site after dark.

Apparently the pair deserted on July 3, for during a few minutes' inspection that morning no birds were noted on the premises. The owner started a noisy diesel generator at 9 p.m. when it was already dark and the swifts should have been roosting, but none was present. During frequent trips throughout the summer I failed to find any birds there, and to judge from the absence of droppings on the paper spread on the floor below the nest no swifts had entered after July 2. When candled with a flashlight on July 3, their remaining egg did not appear any more developed than it did on June 29. The egg that had been transported to Tract C hatched on July 10.

I carried out a somewhat similar though unplanned experiment at Tract C on June 20, 1952. I had their fifth egg in my hand to weigh it at 6:50 p.m. At 7:06 a bird was on the other 4 eggs when I was ready to replace the egg. The swift did not appear uneasy and incubated until 7:48, but it departed without being relieved by its mate. I then replaced the egg.

Attentive periods

The chimney swift begins to incubate when the next to the last egg has been deposited, according to Amadon (1936: 216), Kendeigh (1952: 98), Sherman (1952: 44) and others. Both sexes incubate.

After watching swifts for many years, I felt that the female did a little more than half the incubation, for her attentive periods were often longer. In support of this impression (and to demonstrate the variation in length of attentive periods) I have presented some of my data in tables 14, 15 and 16.

A few explanatory remarks are necessary, particularly for table 16. If the first bird to be observed on the nest was the male, there will be a time entry under his column. Nothing will appear on the same line under the female column. If the female came in and relieved her mate (or came in after the male had departed) her attentive period is entered on the next line in her column. On June 18, 1951, (see table 16) the female had two successive attentive periods which are listed under one another. In the tables are several incomplete determinations, indicated by dagger (†) signs after the figures. When the first entry for any particular day carries

TABLE 14
Attentive Periods of Chimney Swifts
(Tract B, smaller barn, 1950)

DATE	MALE ? — #777	FEMALE ? — #668
June 27	31†	.....
	.....	81
	108	.....
	.....	134
	41†	.....

† Bird on eggs when I arrived, or still on when I departed.
Time in minutes. The eggs began to hatch on July 3.

TABLE 15
Attentive Periods of Chimney Swifts
(Tract A, 1950)

DATE	MALE — #041	FEMALE — #648
June 21	91	....
June 22	....	29
	34	....
	....	35
	20	....
	....	8†
June 26	....	26
	59*	....

† Birds on eggs when I arrived, or still on when I departed.
* Bird departed without being relieved by mate.
Time in minutes. The eggs began to hatch on June 30.

a plus sign, it means that swift was on the eggs when I arrived. If a dagger follows the last entry, that bird was still incubating when I left the site.

The data in tables 14 and 15 are not sufficient to substantiate my feelings that the female chimney swift incubates more than the male. However, table 16 does support it. The average of the male's four *complete* attentive periods is 105 minutes, while the female's average for three complete periods is 159 minutes. A calculation that includes all complete periods and incomplete periods longer than 34 minutes (the shortest complete period recorded) gives 105 minutes as the average attentive period for the male and 118 for the female.

Kendeigh (1952: 96-97) studied this species' incubation in 1932 and found that 11 full attentive periods for one of the birds averaged 34.8 minutes long, while 8 complete attentive periods by the mate averaged 29.4 minutes. At a nest in 1938 Kendeigh did not record attentive period lengths, but he reported that 8.9 hours of observation gave an average of over 33.2 minutes for 12 attentive periods. The range for single periods was from 7 minutes to more than 135 minutes. He said that "an average of 31 attentive periods at both these nests gives 32.4 minutes as the usual length of time a bird sits on the nest at a time." This contrasts with my data in

that the shortest complete period I recorded was 20 minutes. I noted 6 periods that lasted longer than his 135 minutes. Also, I recorded 23 periods longer than Kendeigh's average of 32.4 minutes.

TABLE 16
Attentive Periods of Chimney Swifts
(Tract C, 1951)

DATE	MALE — #561	FEMALE — #036
June 15	.....	7†
	80*	20†
June 16	.....	55†
June 17	34	.....
	.....	52*
June 18	.....	15†*‡
	.....	216*
	112†	.....
June 20	50†	210*
	69†	.....
June 21	.....	45†
June 23	.....	179†
	138†	.....
June 24	.....	2†
	160	.....
June 25	152†	66†

† Bird on eggs when I arrived, or still on when I departed.
* Bird departed without being relieved by mate.
‡ Was probably frightened out by a woodchuck (*Marmota monax*) that whistled loudly downstairs.
Clutch complete by June 10; began to hatch June 25.
Time in minutes.

One would expect attentive periods to grow longer as incubation progressed, yet my observations of incubating birds did not bear this out. Table 16 is a good example of this species' erratic incubation behavior.

Evidently the length of an attentive period depends primarily on when the mate returns to relieve the sitting bird, since it was distinctly uncommon for a sitting bird to leave the eggs unless the partner was there to replace it. Tables 14, 15 and 16 indicate this fact. Lack (1952: 202) expressed the same belief concerning the common swift.

Some of the longest attentive periods plainly taxed the birds' endurance, especially at Tract C when the sun beat down on the iron roof and the temperature at the nest rose to 90 degrees F. After the first hour on a hot day the incubating swift became noticeably uneasy. It fidgeted on the nest and occasionally called. Often it chippered and suddenly flew off to a point as much as 2 feet below the nest. In a minute or two it fluttered back on the eggs. This might be repeated several times before the bird flew directly out, unrelieved by its mate.

Data of this sort were difficult to obtain in quantity. Frequently I took my lunch with me when I was studying incubation, so that

I could spend 5 or 6 successive hours at a nest. However, the unusual length of some of the attentive periods, plus occasional lengthy inattentive periods, often resulted in my obtaining only 2 or 3 attentive period lengths over a 5-hour watch. Often I had to leave a site before a sitting bird was relieved.

Three birds at a nest

Many bird students have pondered the matter of three chimney swifts at a nest throughout the breeding season and, next to the problem of sex determination, this aspect of swift behavior has intrigued me most. Fortunately, such a situation was found at Tract B in 1950. The three birds were all returns from the previous year; two had nested together in the same building (and in the same nest) in 1949, while the third was one of their two 1949 young. Their other 1949 offspring was not captured during 1950.

During the many hours I spent watching incubation, the "odd" bird, number 784, was never seen to take a turn on the eggs. On June 27th I passed 7 hours in continuous observation but number 784 made no appearance. Only once (June 29th) was it noted on the nest after dark, and at that time one of its parents was on the nest with it.

However, number 784 did take a very active interest in the nestlings and, from what I saw, fed them more than either of its parents and perhaps more than both parents combined. Twice it was found brooding the young after dark; on July 13th it was on the nest with one of its parents, and on July 20th with both. Also of interest is the fact that number 784 was once (July 5th, when the nestlings were two days old) discovered roosting on the wall at the opposite end of the building. This is the sort of thing that happens when a "stray" swift wanders into an occupied site to roost for the night—it is not accepted into the family group and will be found roosting at some distance from it.

I do not think the "odd" bird at Tract B was actually a parent of the three young, my reason being based on the roosting and incubation data presented above. Most likely it represented a nonbreeding individual permitted to share its parents' nest site and some of their duties.

In his revealing paper on extraparental cooperation in this species, Dexter (1952a) recorded 22 cases where three birds associated together at a nest and 6 instances where 4 birds associated together. In some combinations the odd birds were yearlings (offspring of the adults occupying the air shaft?) or adults in their last

years of life. However, some combinations broke up after a year or two and the individuals bred with single mates in the normal fashion. Males were involved more often than females in group nestings.

Nest relief

Chimney swifts go through a stereotyped procedure when they change places on the eggs or young. This is the usual chain of events: A bird enters and lands below and to one side of the nest. In less than a minute it gives the well-known chipper call once, twice and perhaps three times. Generally, the incubating bird flies off immediately; often it lingers and preens for 1 to 5 minutes, but just as often it leaves directly. The newcomer flutters up to the nest and gets on the eggs within a minute after the mate got off.

The eggs are rarely left uncovered for any appreciable length of time. Frequently a sitting individual leaves the eggs as the mate gets on, so they are uncovered for only a few seconds. The usual position of incubating swifts is facing the wall, either head-on or at a slight angle. Often they tug at different sticks as though testing them. At this time, too, the birds add more saliva to various places, including the semicircle above the nest. It is common for a swift to enter a site with a twig, relieve the sitting mate and add the twig to the nest while sitting on the eggs.

Incubation period

In 1941, I determined the incubation period for the Tract A chimney swifts to be 19 days. The only precise determination I was able to make, it proved to be one of average duration. The swift's incubation period varies. Widmann (1922: 57) said the egg required 17 to 19 days. Miss Sherman (1952: 59) gave a range of 19 to 21 days (19 was most common) *from the laying of the last egg*, so her data are more accurate. Amadon (1936: 216) and Kendeigh (1952: 96) both noted 19-day incubation periods. MacNamara (1918: 41) studied a pair that hatched their eggs in only 16 days.

By comparison, the incubation period of the common swift averages 19.6 days (Lack, 1951: 514), but the same species required an average of 20 days in Switzerland (ibid.) Arn (1945) gave 21 days as the mean for the Alpine swift. For the white-rumped swift the usual period is about 21 days, according to Moreau (1942: 35). Incubation periods for the other American representatives of the family have not been published.

Hatching

The first sign that an egg had hatched was usually the two halves of the shell on the floor under the nest. The adults did not carry the egg shells away but dropped them from the nest within two hours of hatching. Hence, a good way to check on hatching without frightening the adults was to examine the floor from a distance.

The chimney swift's eggs do not hatch all at the same time. In 1941 the Tract A silo nest held four eggs on the afternoon of July 18. On July 19 I noted two hatched eggs at 11:30 a.m.; the others were still unhatched at 7 p.m. The third egg was hatched by 11:30 a.m. on July 20, but at 6 p.m. the last egg had not hatched; it was hatched by 10:30 the next morning.

At Tract B (the smaller barn) in 1950 the three eggs had not hatched by 5:13 p.m. on July 3. Two had hatched by 10:35 p.m. and the third hatched by 11:55 the next morning.

Five Tract C eggs had not yet hatched at 4:20 p.m. on July 7, 1950. The first two were hatched when I made a check at 1:50 p.m. on July 8. The third hatched sometime before 11:30 a.m. on July 9. Two eggs did not hatch. On one occasion (June 25, 1951) I was in the blind at Tract C when an egg hatched. At 5:35 (while the female was sitting) I heard the weak squealing of the first of their four young. The second hatched between 9:15 and 11:15 p.m. the same day. By 11:25 the following morning the other two had hatched.

Hatching success

Hatching success for the chimney swift has not been reported; nevertheless, many short notes scattered through the literature suggest it is high. During these studies I determined hatching success for 20 nests as follows:

TABLE 17
Hatching Success in the Chimney Swift

EGGS IN SET	NUMBER HATCHED			
	5	4	3	2
5	5*	3	1	
4		6	2	1
3			1	
2				1

* These figures represent the number of sets.

The 20 nests contained 86 eggs, 77 of which hatched. Hatching success was therefore 90.7 percent. Lack (1951: 515) in his study of the common swift in Great Britain found that 78 percent of the eggs hatched; Weitnauer (1947) recorded the same hatching per-

cent in Switzerland. Lack and Arn (1947: 189) reported 94 percent in the Alpine swift, while Moreau (1942: 34) found 89.2 percent success in the white-rumped swift.

Weight of newly hatched young

The weight of the 1951 Tract C nestling 1½ hours after it hatched was 1.35 grams. The other three eggs were pipped and I could plainly hear the chicks cutting away at the larger ends. Two of the eggs weighed 1.7 grams and the third weighed 1.6. One of the 1950 Tract B nestlings weighed 1.65 grams about 14 hours after it had hatched. I recorded the same weight for a 1950 Tract C young of approximately equal age.

CARE AND FEEDING OF NESTLINGS

The feeding process

Practically every bird book and paper on the chimney swift states that this swift (like others of its family) feeds the young by regurgitation. (As far as David Lack knows [personal communication] regurgitation does not occur in the common swift; he has observed a food-bulge on the first day that the young hatch.) This is true only in the first week. I watched adults feed nestlings on many occasions and noted their actions carefully. From my field notes I have abstracted an observation which represented typical feeding behavior when the young were less than one-week old. It was made at Tract C on June 26, 1951, when the young were not yet 24 hours old:

11:25 a. m. — male on young as I slipped into blind.

11:42 — female entered, landing on rug about 15 inches northeast with a chipper call. In a few seconds the bird chippered again.

11:43 — male, clutching front edge of the nest, fluttered delicately and then moved off toward the right in a creeping, fluttering fashion. (A swift rarely flew off its young.) As the male moved away, the female fluttered over and onto the nest. Then it fed at least three young, in this manner: First it fed, then stretched its neck and head upward, plainly regurgitating. It fed again, regurgitated again. The adult fed five times, regurgitating after each feeding. It did not feed after the last regurgitation. The process lasted a minute.

Figure 9. To scold an intruder, the chimney swift snaps its wings together while in flight. After slowly arching its back and raising its wings, as shown here, the bird springs backward into flight and produces several loud snaps before coming to rest. Photographed July 1, 1951.

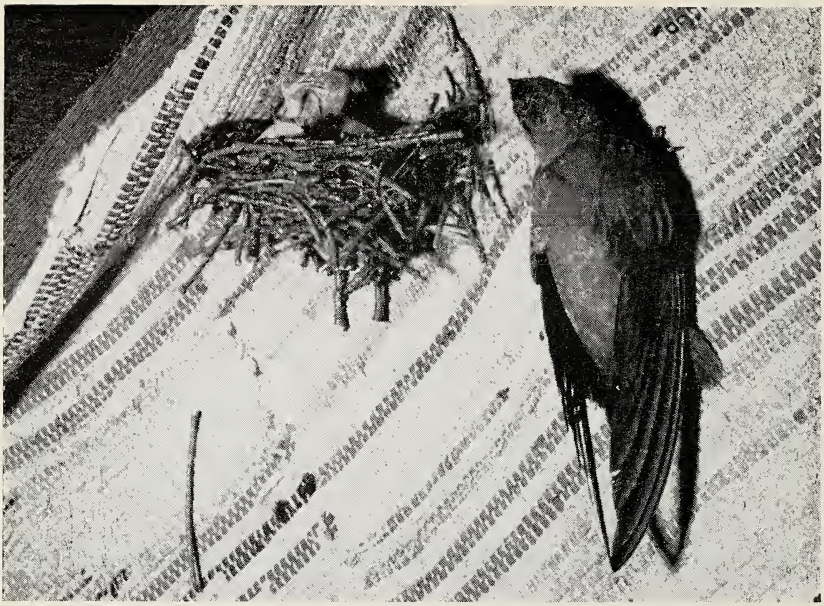


Figure 10. A female chimney swift approaching her nest with food as the blind young beg. The sound of wings was the strongest begging releaser throughout nest life, although sight of the adults (after chicks could see) or their chipper call also elicited the gaping reaction. Photographed July 6, 1952.

Figure 11. A female swift, throat distended with insects, regurgitating food for newly hatched young. She will feed several young on this visit, then brood. The male (left wing painted white with model airplane dope) had been brooding; he will depart soon for food. Note the many "test" sticks on the couch cover. Photographed June 30, 1951.

Figure 12. The female now broods the nestlings, but her slightly distended throat suggests she has retained some insects and will feed them again before being relieved by her mate. Photographed July 6, 1952.

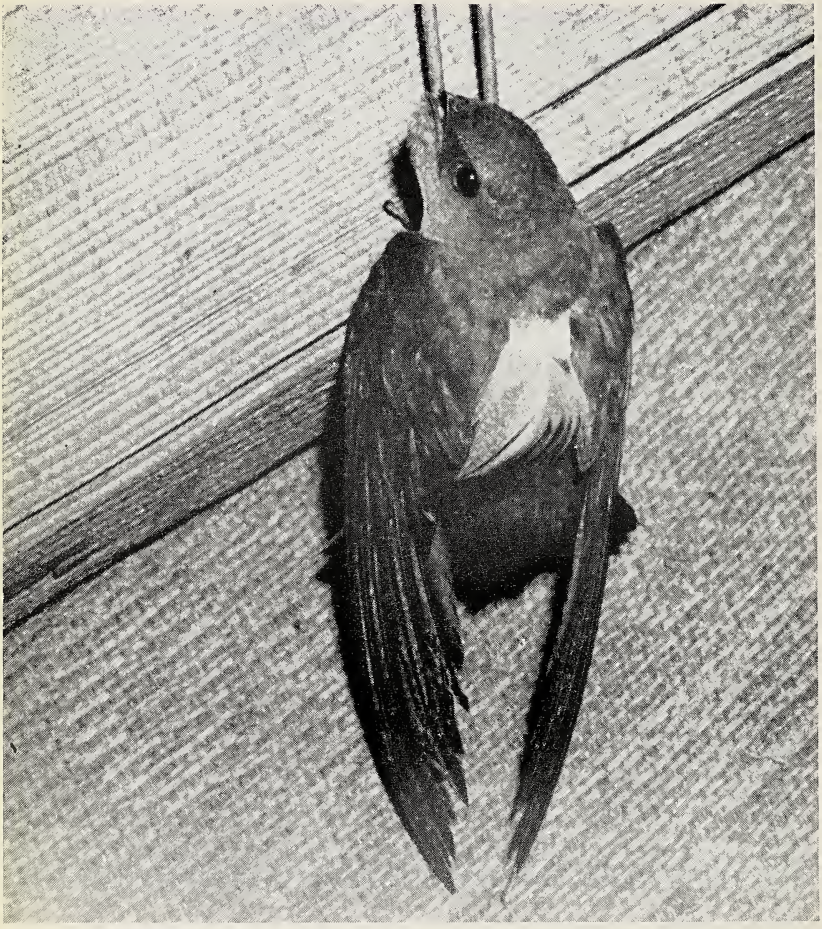


Figure 13. This swift's gullet bulges from a pellet of insects which she will feed to only one nestling. For recognizing individual birds, painting the wings was superior to feather marking shown here. Photographed July 22, 1950.

11:44 — female settled on the young. The male, after first fluttering, took flight, and left the building. He deviated from normal behavior in that he did not chipper before he took wing.

During the first three days of nest life, the parent arrived with the insects for the first young in its mouth, and the insects for other feedings (at that visit) in the gullet. I never saw a parent go through regurgitation movements before it fed the first nestling. It did regurgitate before each succeeding meal, but it did not feed after the last regurgitation.

In the literature of the chimney swift, Bolles' description of regurgitation is apparently the only one. A pair had built in his chimney and the writer observed them by means of two mirrors arranged like a periscope. Of feeding Bolles (1894) wrote:

> She came to the nest, mounted its edge and leaned toward the open-mouthed young. Then she moved violently and seemed to hang over the infants, to pound them, shake them and push them back and forth in a singularly unkind way. Seeing all these things by double reflection and in the dim light of the chimney, I could not be certain of the details, but all that I saw reminded me of descriptions I had heard and read, of feeding young birds by regurgitation, while nothing that went on looked like the quiet and matter-of-fact process of dropping a fly in the little bird's gaping mouth. It seemed to me that the parent inserted her bill into the young's throat, and then presumably pumped into it, by the violent motions which she made, a portion of the food previously swallowed by her.

If Mr. Bolles actually saw what he described, he did not witness typical regurgitation feeding. Throughout these studies I failed to see anything about the process that could be interpreted as "unkind." The swifts I watched placed the food in the nestlings' mouths gently. Then the parents extended their necks nearly vertically, pumped them up and down several times, and fed the next youngster. On the few occasions when I observed feeding at close range I noticed that the adults' eyes were shut at the moment they inserted the food. Day (1899: 80) also noted this.

Early in nest life I was not able to ascertain how many young were fed at one visit, as it was dark in the barns and I was below the nests. However, I rarely saw adults regurgitate less than three times and it occasionally happened six times. I surmised that usually two or three received food at a trip during the first week.

By the third day of nest life the parent swifts appeared to feed only one youngster on a trip, but occasionally it fed two. From the

blind I had previously noticed that, after the last regurgitation, there was often a bulge in an adult's gullet or throat not evident when the bird first entered to feed. On two occasions when swifts came in while I was at their nests to examine the young, the birds went through the feeding process 3 feet from me and ended with some food still in their throats. On one of the occasions I stood motionless on the top board of a step ladder for one hour; the bird still had not fed the last of the food when I departed. In the other case, a bird brooded with the food bulge in its throat for 22 minutes, then flew out with it when the mate came in to feed. Frequently I saw a brooding adult poke about among the young with its bill 10 or more minutes after it fed them. This usually elicited begging cries. Since at these times the bird raised its head and stretched the neck, as though regurgitating, I was almost certain that the bird had fed the nestlings again. This supposition was supported by the comments of Kingston (1981: 99-100). As he noted:

> there was something about their manner of feeding the young which struck me as remarkable. When one of the parent birds returned from hunting and took its place on the nest, . . . , it would not proceed to feed . . . till after an interval of several minutes. Then without uncovering the nest it would put its head down and make a sort of contortion of the whole body, and at the same time the young would be heard to peep. This action would suggest that the food, instead of being carried in the bill . . . is disgorged from the crop after the manner of the vultures and some seabirds.

My observations differed from Kingston's in that the parents always fed at least one young before getting on them to brood.

By the sixth day, on the average, the adults fed only one young per visit. They no longer regurgitated the food because they carried it *not* in the gullet but in the mouth. The food was not a loose assortment of insects but a definite pellet or "ball," as European writers would say, that contained tangled insects and saliva. These ovoid pellets usually measured 1 x 1½ centimeters and weighed from 0.3 to 0.9 grams. They created a pronounced bulge in the throats and gullets of adults or young. (See illustrations; also, Lack, 1954: 64, for a picture of *Apus a. apus.*)

The parent placed its bill as far as possible into the gaping mouth of a young one. As the photograph shows, the parents closed its eyes in the process.

To study food habits, I devised a method of obtaining pellets. When a parent entered and fed I watched carefully to see which young received the pellet. Since I wanted to keep disturbances to

a minimum, I rarely flushed the parent. Instead, I waited until it departed. Then I climbed hastily to the nest, grasped the young swift's neck to prevent it from swallowing, and took it into the blind with me. The pellet was gently forced out and placed in a vial of alcohol along with a data slip.

Taking food from the nestlings introduced a problem. Young chimney swifts have the voracious appetites one associates with nestling barn swallows, for instance, but they are fed much less often. So, to preserve the usefulness of the food habits data, I gave the young substitute meals whenever I took their pellets. I used to beat the grass and shrubbery with an insect net until I had enough insects for several meals. When I had given a bird an amount of food equal to what I had taken from it, I put the swift back in its nest. As a rule I got the young swifts back in the nest before the next adult arrived to feed. Should a parent come in too soon, I held the nestling until the bird departed. Sometimes I got to the young only to find all with pellets in their gullets. I found it was safe to remove all but one nestling; then if a parent came in before I had finished, it fed the single young and evidently did not detect the decrease in its brood. When it flew out, I put the others back.

After the 10th day the parents no longer got on the nest to feed. At barn nests the birds generally landed a foot or more below the nests and on the side away from the window entrance. In a moment or two they fluttered up to the side of the nest and, usually, fed the nearest begging youngster. After that, the parent often brooded.

Begging releasers

The young chimney swifts were like other nestlings—they were almost always hungry. Four things served to trigger the gaping reaction. During the first week, when they were brooded more or less continuously, they gaped as soon as the adult moved on them. Then, gaping was short-lived. Rapidly they became conditioned to the fluttering of a parent as it got off to permit the other adult to feed, so their begging was louder and more prolonged—up to 2½ minutes sometimes. If no parent was on them when a bird arrived with food, the sound of fluttering wings close by released the begging action. After the third day the young were also conditioned to the parents' chipper call, which they nearly always gave as they alighted. While it brought forth gaping, it was never—throughout their nest life—as powerful a releaser as the sound of wings.

At infrequent times the young were not hungry and did not respond to the voice or wing sounds. Usually they reacted when an adult touched them with its bill, and one young speedily communicated its begging to the others. Once I saw them fail to react to prodding; the male brooded them for 58 minutes and all the while the food bulge in its throat was noticeable. At the mate's return, the male got off immediately and flew out after one minute. His movements released begging that lasted 1½ minutes, and the female fed soon after.

After their eyes had opened, the nestlings gaped at the sight of the adults, yet the sound of approaching wings always prompted the strongest begging. Frequently the young were in deep sleep and none heard the parent's arrival chipper. A second, seemingly louder chipper brought forth only a few brief *chack* or *creep* notes. Then the parent fluttered to within 6 inches of them and instantly the entire nestful broke into raucous begging.

Young out of the nest were highly sensitive to the sight and sound of the parents. It was practically impossible for an adult to enter—no matter how quietly—without an immediate response from the little swifts. They seemed to be waiting for every meal.

Voice of young

At first the nestling swifts uttered weak, squealing notes as they begged. In three days these grew stronger and sounded like a repeated *cheh-cheh-cheh* . . . which could be heard easily at 50 feet. By their fifth day, the young gave a loud, rhythmical, ratchet-like *chuh-chuh-chuh* . . . that did not resemble the begging notes of any of the common passerines of this State with which I am familiar. With the growth of the young, the pitch of the notes rose and the intervals between them shortened, so that by the fifth week it was evident that they were becoming the familiar chipper call of an adult. Amadon (1936: 217) was therefore correct when he guessed that the nestlings' food calls would develop into the notes of the adults.

If they were disturbed, young swifts gave quite a different series of notes which nearly all ornithologists have called food calls. I did myself for some years. I could elicit these "disturbance" calls at any time by making a sudden loud noise. When I removed the young from their nests, they invariably gave the calls and they continued as they clung to my sweater or trousers while I climbed down. The notes were a loud, rasping *raah-raah-raah* . . . that several persons said sounded like bats! I do not know where they

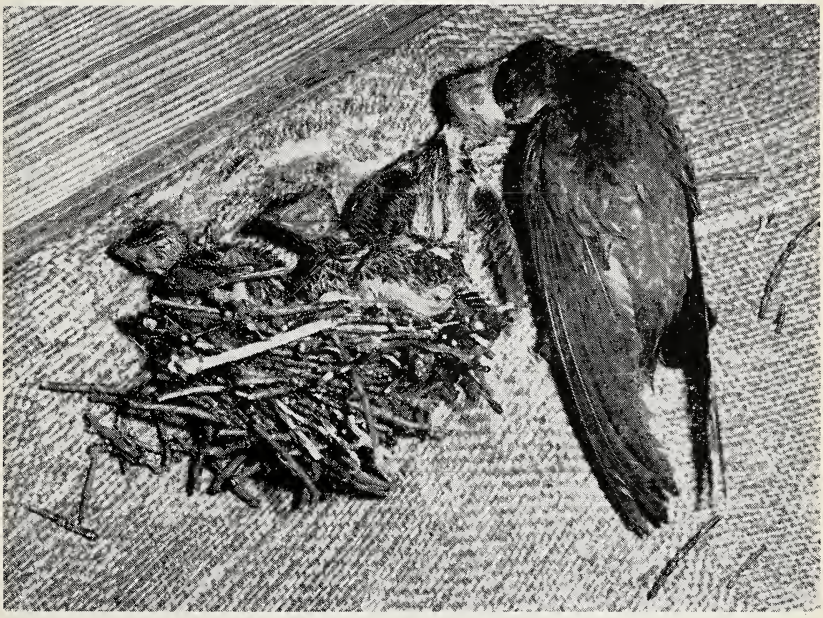


Figure 14. The adult places the food pellet well down in the nestling's gullet. The other three young are not hungry, so they do not beg. Photographed July 8, 1951.

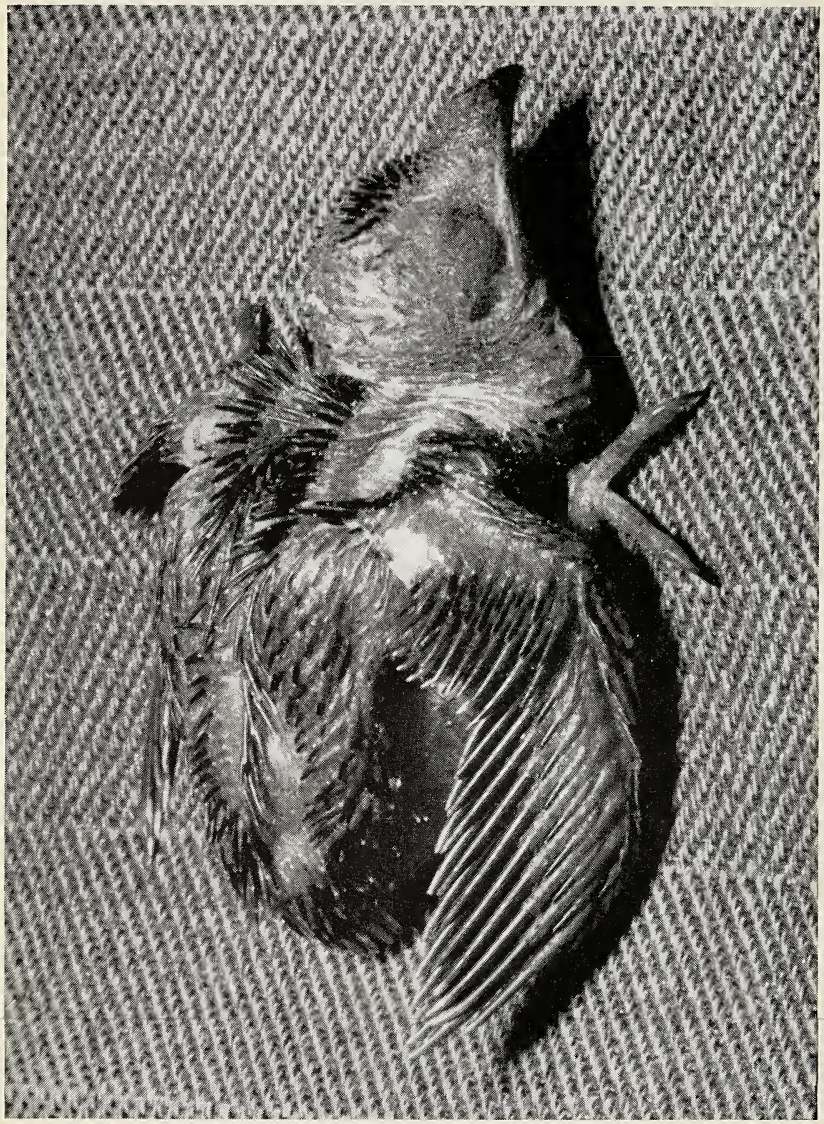


Figure 15. The chick is clinging upright to a vertical surface. The pellet of insects, which causes a pronounced bulge, may be retained in the gullet for three hours before being swallowed. Food pellets weighed from 0.2 to 0.9 grams and each contained hundreds of small insects (chiefly Diptera, Homoptera, Hymenoptera, Ephemerida and Plecoptera) and occasional spiders. Photographed July 6, 1951.

got their impressions, though I had to agree that the notes were not very birdlike. Miss Sherman (1952: 52) likened them to the "fear cry of a [nestling?] flicker."

When a nestling was disturbed, it commenced to call and its nestmates quickly joined it to produce a noisy chorus which stopped, a minute or two later, as abruptly as it began. It was interesting to note that the parents sometimes prompted disturbance calling when they changed positions on the young, but usually only one young called and then not longer than 4 or 5 seconds.

A disturbed nestling did not always give the *raah* call. If I poked one, it emitted a sharp *chack* at the same time tha tit twitched and tried to crouch deeper in the nest. However, the others, pressed close to the disturbed one, reacted to the twitching with a few *chacks* and twitches of their own. The responses weakened with repeated poking and frequently gave way to *raah-raah* calls.

Food

Throughout their nest life the young swifts at Beaver Kill were fed small insects that seldom exceeded 5 millimeters in length. Examination of more than 1,000 insects showed that the chief food items, in frequency of occurrence, were Diptera, Homoptera, Hymenoptera, Ephemerida and Plecoptera. These five orders accounted for approximately 95 percent of their food. Other orders recorded were Coleoptera, Hemiptera, Trichoptera and Siphonaptera. Spiders (Arachnida) were found on occasion throughout the summers.

The presence of the fleas calls for explanation, yet I have none that is satisfactory. In a pellet that I took one minute after the nestling received it from the female parent, I found three fleas. I sent them to Mr. Ronald Ward, a doctoral student specializing in ectoparasites at the University of Chicago, and learned they were females of *Orchopeas leucopus* (Baker)—the common flea of the deermouse *(Peromyscus leucopus).* Mr. Ward wrote that this flea is widely distributed from Alberta and Arizona eastward to the Atlantic coast, but to his knowledge has never been associated with birds. He said that Clay and Rothschild have pointed out that swarms of adult fleas have been observed leaving birds' and mammals' nests only to be found later in unusual situations. Deermice inhabited the swifts' barn and on one occasion I saw one climbing on the roof timbers near the birds' nest. It is therefore quite possible that the fleas left a mouse nest, got on an adult and were picked off and incorporated in a food pellet, or got on the young bird and were picked off by it.

In the first week the young received the majority of the smallest food items recorded. They included numerous insects only 2 to 4 millimeters long. Bibionidae, Dolichopodidae and Phoridae (Diptera), Cynipidae (Hymenoptera) made up the bulk of these small forms. One Scolytid beetle—the smallest specimen noted—was a scant 2 millimeters.

After one week of age the nestlings continued to get mostly small insects, but larger species were added. Items like *Aphrophora quadranotata* (a Homopteron about 6 millimeters long) became one of the most common food items. Ephemerida, Plecoptera, muscoidean flies and larger Hymenoptera, Tipulidae (Diptera) and Cicadellidae also appeared more often in the pellets. Rather than a change in the rank of the orders fed the young, there was a partial shift to larger species within the groups.

It was plainly evident that the swifts took advantage of any hatches that occurred. I recorded instances in which the insects in a pellet were exclusively Ephemerida, or a species of *Myrmica* (Formicidae, Hymenoptera) or *Aphrophora quadranotata.*

Little has been published on the food of this swift. Warren (1890: 183) examined the stomachs of 12 adults and listed, in frequency of occurrence, the following: beetles, small dipterous insects, small winged insects, other insects and a caterpillar.

Pearson (1911: 118) quoted a letter from W. L. McAtee which stated that

> the bird's food consists almost wholly of insects, and beetles, flies and ants are the principal items. It gets many beetles (Scolytidae), the most serious enemies of our forests, when they are swarming, and takes also the old-fashioned potato beetle *(Lema trilineata),* the tarnished plant bug *(Lygus pratensis)* and other injurious insects.

Termites (Isoptera) were recorded by Blake (1941: 104). My findings differed sharply from those of Weed and Dearborn (1916: 178), who stated:

> Three speciments studied by Professor S. A. Forbes had eaten ants, moths, ground beetles, rove beetles, plant beetles, flies, bugs and spiders. The young are fed largely on grasshoppers when these are abundant, and at other times on various kinds of insects.

I failed to find any moths in the food pellets. If I tried to feed a nestling a moth it usually "spit it out," but when I removed the insect's legs, wings, and some of the body scales the swift was likely to accept it. They did not like grasshoppers, either; the long legs seemed particularly annoying. These Orthopterons were abundant

in the area but the young did not receive any. Bumblebees, presumably because of their dense hairs, were also disliked. However, I had no difficulty in getting the young to eat the insects to which they were accustomed.

Davis (1937: 223) said that gullet examination of young Vaux swifts indicated their food was largely leaf hoppers (Cicadellidae). Flies were the dominant food in 21 white-throated swift stomachs analyzed by Cottam; Coleoptera, Hymenoptera and Hemiptera were represented in descending order of occurrence (Bent, 1940: 315).

In Switzerland, Arn (1945) found that Diptera, plant lice, beetles, and Hymenoptera (chiefly wasps) were the principal food items of young Alpine swifts. He also reported two butterflies. Moreau (1942: 44) noted a preponderance of small insects in the food of nestling white-rumped swifts. Hymenoptera predominated, followed by Coleoptera; Hemiptera, Homoptera, Isoptera and one Lepidoptera were also found in small numbers.

Following an exhaustive study of the common swift's food, Koskimies (1950: 25) concluded that the main orders were Hemiptera, Diptera, Hymenoptera and Coleoptera.

Where the adults went for food

I admit at the outset that my knowledge of this aspect of chimney swift biology is incomplete. One thing was certain: the birds seldom collected food near their nests. After feeding its young, a swift left the building and soon disappeared from view. Thus, colormarking was little help, generally. One day I saw the Tract C male fly over a hayfield about a quarter mile away, and from the Ephemerida they fed their young I deduced that the pair often fed over the Beaver Kill, about one-eighth mile from the nest site.

There can be no doubt that the Beaver Kill chimney swifts foraged far from the nests, otherwise I would have seen them near the sites. It is likely that they wandered a mile or more, since I sometimes saw small groups over contiguous forest areas. Additional support is the following unusual incident. On June 17, 1951, my mother visited the Huggans on the other side of the mountain and 1¾ airline miles from Tract C. She told them about my painting the swifts' wings, whereupon Miss Huggans said her brother Bill remarked a few days before that he had seen two "birds" each with paint on one wing. One had a yellow wing and the other a white one, he said. If Bill was correct, he had seen a swift from Trace C and one from Tract B, some 2¾ and 4 airline miles away respectively.

Feeding at a distance from the nest by the chimney swift is in accord with the habits of other swifts (cf. Arn, 1945; Koskimies, 1950).

Our swift does not obtain all its food from the air. On several occasions I have seen a bird flutter up to the tip of a leafy branch as though picking off an insect. This sort of feeding behavior would explain the occurrence, in a pellet, of species such as *Jalysus Spinosus* (Neididae, Hemiptera) which, according to Comstock (1930: 108-109) "belongs to a family of sluggish insects found in the undergrowth of woods and in meadows and pastures."

Feeding frequency

Analysis of the 1950, 1951 and 1952 nest observations indicated considerable irregularity in feeding behavior. During their first week, the young were fed on the average of once every half hour. They seldom received food within 20 minutes of the preceding visit. In the second week the time interval lengthened to an average of 45 minutes. After the young had left the nests (at the close of the third week) feeding became quite erratic although the tendency was for each parent to feed about once an hour. More than two hours sometimes elapsed between food trips. This behavior was markedly different from passerines, which increase their rate of feeding as the young grow older (Nice, 1943: 230).

Miss Sherman (1952: 49) also noted the swift's irregularity, particularly during the day. She said the average time between feedings "seems to be about an hour," although she did not indicate how old the young were when she arrived at that average. Kendeigh (1952: 97-98) recorded feeding at the rate of 3 times per hour in the first 4 days of nestling life, 4 times an hour until the age of 2 weeks, and once an hour from the 16th to 20th days. However, his data were based on only one nest and may be atypical.

The common swift is similarly erratic in feeding behavior (the Lacks, 1952: 534). The African white-rumped swifts that Moreau (1942: 42) studied also exhibited irregularity in this respect.

Miss Sherman (1952) and I both noticed that there often occurred a period of frequent feedings after sunset. Since my birds were colormarked, I learned that the female brought most of the food at these times. On one occasion she fed 13 times in a 48-minute period, averaging once each 4 minutes. However, pellet analysis revealed that the meals were not of normal size. Often they consisted of only one or two Cercopids, frequently *Aphrophora quadranotata.*

Experiments in moving nestlings

In certain of its ways the chimney swift exhibits stereotyped behavior. Though several panes be missing from its exit window, the bird will steadfastly fly through the same opening on every visit to the nest. When it arrives, it almost always alights on the identical little area nearby each time. Rarely does it fail to call on landing, and again just before it flies out of the nest site. Move its eggs to a dummy nest close to its own and the swift will not recognize them. Instead, it will sit on its empty nest.

I tried moving the young to a dummy nest, and the adult ran true to form. On July 5, 1950, I put the three Tract B young (two days old) in a dummy nest, 25 inches below their own, at 3:25 p.m. Number 777 entered at 4:13, landing 7 inches west of the young. They did not respond to the adult's arrival chipper. When 777 chippered, took wing, and came to rest 12 inches above them, the nestlings begged hard for 1½ minutes. However, 777 ignored the food cries and flew up to the empty nest at 4:17; the bird got on and remained on until 6 p.m.! Another adult, numbered 784, came in at 4:50 and the young begged for one minute when the newcomer chippered. (This was the trio described on pages 40 and 87.) They called again when a noisy automobile went by outside at 5:02. From 5:25 onward the young frequently broke into spontaneous begging, but it had no visible effect on the two adults. Number 777 departed quietly at 6 p.m. and 784 followed 4 minutes later. I then gave the young some insects and replaced them in their nest.

An unplanned experiment took place on June 30, 1951. The Tract C male entered at 2:52 p.m. when I had the four 5-day old young out of the nest for weighing. He landed about 2 feet northeast of the nest, chippered softly and fluttered over to it. For several seconds the bird went through the motions of feeding, poking his head downward as though putting food in a nestling's mouth but not regurgitating. Then the male got on the nest where he fidgeted for approximately 30 seconds before he settled down to "brooding." I prepared to capture the bird to learn what food he had brought, but he escaped before I could wield the net.

When the 1952 young at Tract C were 2 weeks old, I placed all 4 in a dummy nest 40 inches southwest by south of their nest. This was at 3:15 p.m. on July 15. The female (number 036) came in at 4:19. She did not chipper, yet the young begged hard immediately even though their eyes were still unopened. The adult had landed between the two nests and within 10 seconds began to flutter up

to her own. The young continued to beg. Before she reached her nest, the parent seemed to realize that something was wrong, for I saw her look down over one "shoulder." In a moment she fluttered down to feed. She departed at 4:21.

The mate—number 561—entered quietly at 4:34; the young heard him and begged hard instantly. As the parent fluttered to the real nest a minute later, he, too, heard the young swifts below and he stopped his ascent. He turned, saw the young below, and backed down to feed one of them. The adult departed 5 minutes after he had entered.

Brooding

It was the rule for a parent to brood after feeding. When the nestlings were in the first week, brooding was practically uninterrupted. The sitting bird waited until the mate came with food, and often appeared to be pushed off by the incoming bird. In the evening, after the sun had set, it was not uncommon for both swifts to be absent from the nest. Color-marking showed that they took these occasions to fly together or to join other swifts in social flights.

After dark one (and usually both) parents brooded. The female tended to cover the young more than the male. This brooding in unison continued regularly till the 12th day, after which the nestlings were too large for both adults to get on them. Continuous daytime brooding ceased after the sixth day.

Nest sanitation

Whether used or unused, a chimney swift's nest is an unusually clean structure. It never becomes soiled by feces and because of its highly porous nature the fragments that flake off the nestlings' developing feathers fall through without accumulating. Even before the young have opened their eyes, I have watched them preen and eat the flakes they removed.

Having observed many nests, I was familiar with the nestlings' procedure in defecating over the edge. When a bird needs to defecate, it wriggles out of the mass of its siblings (this causes a general disturbance and vocalization), backs up to the front edge of the nest, voids the feces over the edge, and then scrambles back among its nest mates, creating another momentary disturbance.

In 1951 I learned what happens before this trait becomes ingrained in the young. The eggs at Tract C were all hatched by June 26. On the following day I saw both adults clean the nest by eating the

feces. This happened again on June 30, when the young were in their fifth day. The only sanitation I witnessed on July 1 occurred when the male dropped feces from the young over the side of the nest. (Fecal sacs do not occur with young chimney swifts.) On July 2, when the nestlings were in their seventh day, two individuals voided feces over the front edge of the nest; one was the smallest bird. Henceforth that was their only method of defecating. Observations in 1952 corroborated this picture of nest sanitation behavior and its development in the young.

An incubating adult voided in the same manner as young, except that there was no struggling to get to the front edge of the nest.

Handling the nestlings to weigh and photograph them invariably brought forth defecation. A single voiding generally weighed between 0.3 and 0.4 grams, while the total amount of feces passed by one bird during handling sometimes equalled a full gram.

Defecation by other American swifts has not been described in the literature. The common swift cleans its nest in a somewhat similar fashion. However, the adults carry only moist feces away; dry droppings accumulate and toward the close of the breeding cycle the parents are less careful to remove fresh feces, so the nests become extremely dirty (the Lacks, 1952: 208).

At least a few hummingbirds indicate their alliance with the swift family through their defecating behavior. Young rufous hummingbirds (*Selasphorus rufus*) discharged feces forcibly over the rim of the nest like nestling chimney swifts and the nest never required cleaning (Bent, 1940: 401). In the white-eared hummingbird (*Hylocharis l, leucotis*) Skutch noted that the female picked feces out of the nest and dropped them to the ground or she ate them. When the young were a little older they deposited droppings on the nest's rim, but the parent did not remove them. Later, the nestlings defecated over the edge of the nest (*in* Bent, 1940: 460).

The mallophagan *Dennyus dubius* was present on all the adults and feathered young that I examined. Eggs of the parasite were attached to the shafts of the crown feathers but apparently nowhere else on the birds. The species is a well-known mallophagan on the chimney swift and Mr. Ward wrote me that it is probably restricted to this bird, although Ewing (1930: 8) has given two other hosts.

Another malophagan—*Eureum ewingi*—has been found only on the chimney swift. Evidently it is a rare species, for it has been recorded only twice in the literature. I did not find any specimens on the birds I examined at Beaver Kill. One swift harbored a species of thrips.

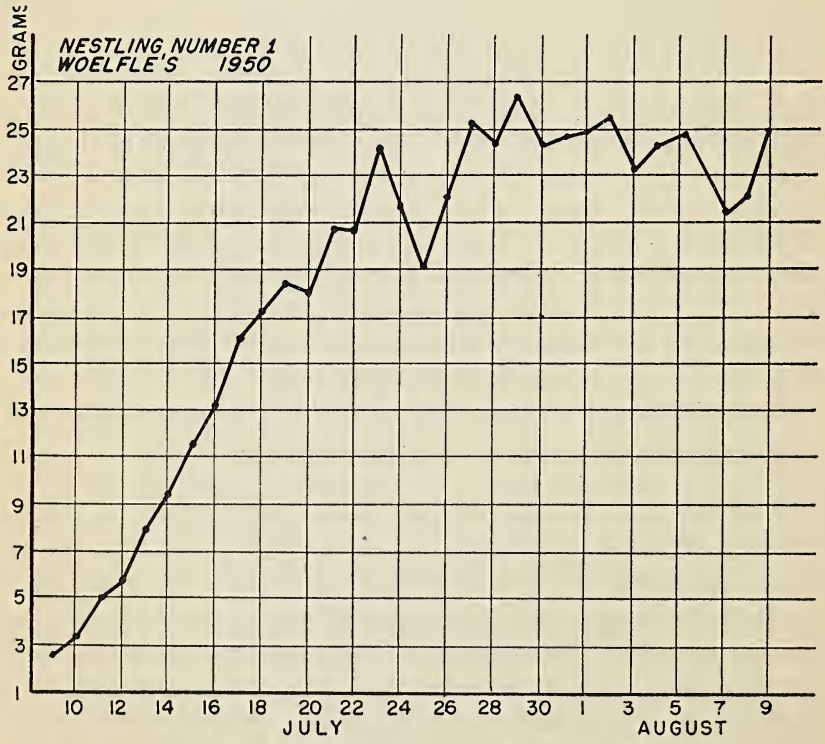
All the nests in the study area were not only free of droppings, but they were devoid of parasites. However, two species of Cimicidae (*Oeciacus vicarius* and *Cimexopsis nyctalis*) have been reported by other workers.

GROWTH OF THE YOUNG

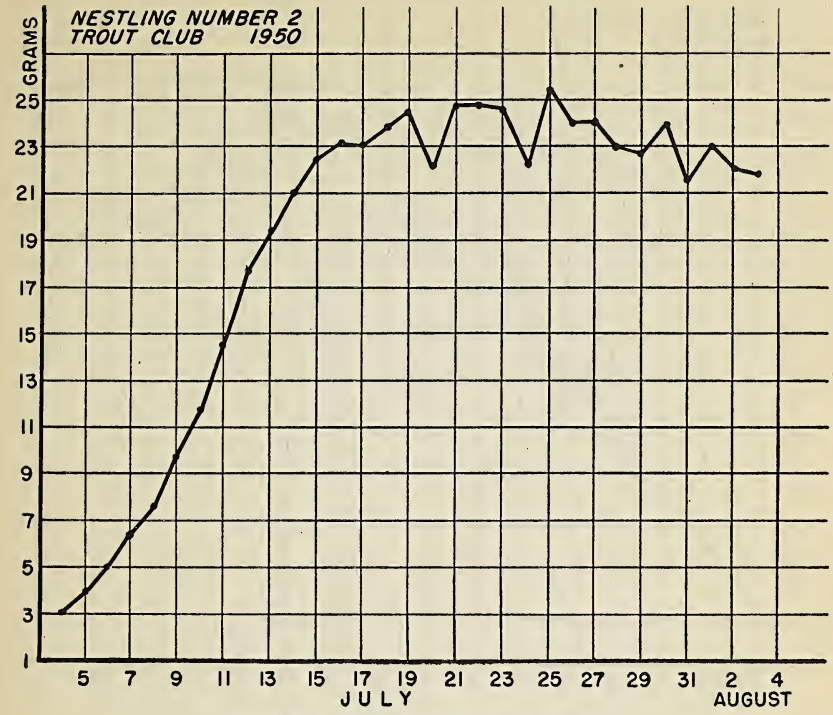
Growth in terms of weight

In the summers of 1950 through 1952 I weighed the young swifts daily at least once. Data were thereby obtained on 15 birds from 4 nests. The patterns of development in terms of weight increases were so similar that I present the growth curves of only one young from each of the four nests. See graphs 2-5.

Perhaps certain features of the curves ought to be pointed out. Maximum weight—which equalled adult weight—was attained by the end of the third week. Henceforth, it slowly declined through a series of losses and gains, caused by the longer intervals between



Graph 2. Weight changes in a nestling



Graph 3. Weight changes in a nestling

feedings and the greater activity of the young as they practiced flying in the buildings.

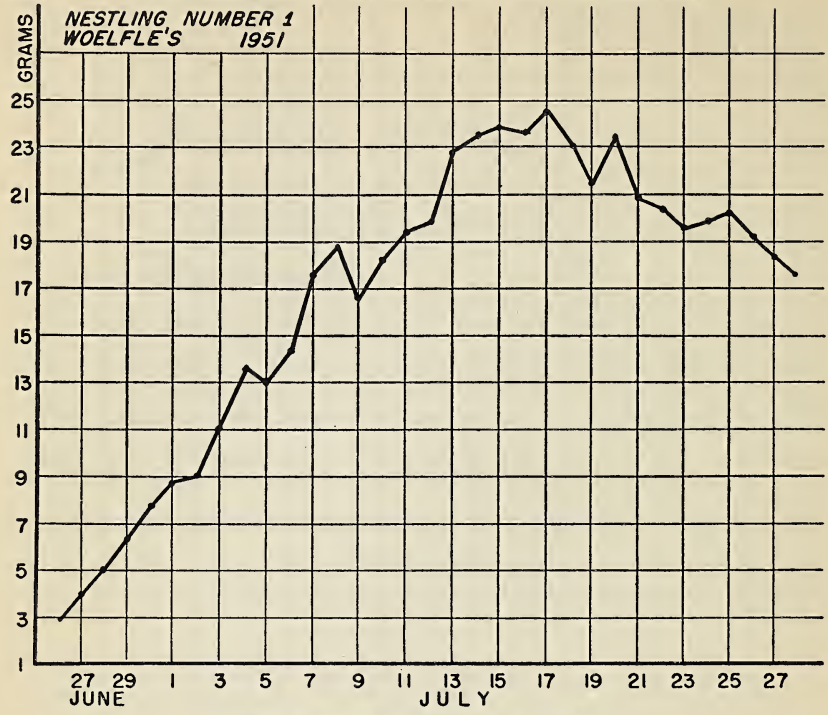
The curves follow the pattern of passerine birds (except the Corvidae) in which

> in the first 10 days the young typically increases its weight 10- to 12-fold; hence reaches 60 to 80 percent of the adult weight. During the next 10 days the increase drops off sharply, so that at 20 days the young bird has reached some 75 to 90 percent of the adult weight, occasionally 100 percent (Nice, 1943: 72).

Growth and the weather

In the growth curves are occasional sharp decreases in weight. In almost every case they were caused by inclement weather. To illustrate the influence of weather on the development of the nestling chimney swift, I have chosen the 1951 Tract C nest (at Woelfle's) for a detailed analysis and discussion. Certain factors besides weather will emerge in the account.

The young swifts were weighed daily from the time of hatching until they left the barn—June 26 through July 27—and their growth



Graph 4. Weight changes in a nestling

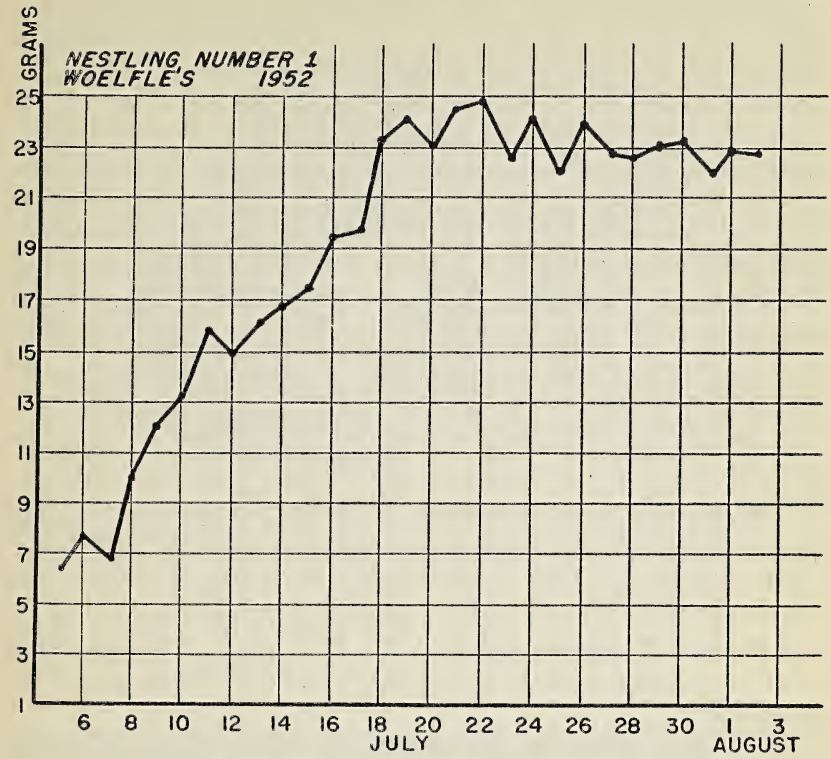
in terms of weight is represented on the graph of nestling number 1.

Maximum weights of three of the brood were attained as follows:

No. 1 — 24.0 grams on July 17
No. 2 — 24.9 grams on July 16
No. 3 — 27.6 grams on July 20

Number 4 was omitted because it died at the age of 16 days. Why number 3 achieved the greatest weight is probably to be explained by the aggressiveness of the bird. Often its prolonged food call, even after being fed, would stimulate the other young to beg anew. It usually begged first, loudest and longest. There were times when its weight trailed behind some of its siblings, but number 3's vigorous begging finally edged them out.

All four young sustained a marked decrease in growth rate between July 1 and 3. June 30 was not what one would think of as a good day for chimney swifts, for, following an overcast morning, rain varying from a fine drizzle to a downpour fell most of the afternoon. Nevertheless, these atmospheric conditions were not so



Graph 5. Weight changes in a nestling

unfavorable as one might think, and as the graph shows the rate of weight increase was lessened but no weight was lost. From 11:55 a.m. to 2:52 p.m. the adults were feeding at the average rate of once every 30 minutes.

The following day began with rain that ended by 10 a.m., after which the sky cleared very slowly, the first blue sky appearing at 2 p.m. Cumulus clouds were not present until 4 o'clock. I did not disturb the parents in any way until 2:30 p.m. and would not have done so at that time had not number 036 (the female) alighted right next to me as I was removing a nestling to get its weight. She had a large pellet in her gullet, and a desire to know what the swifts were catching, plus the lack of food samples for the previous day, prompted me to grab her.

The pellet consisted of 46 insects only one of which exceeded the average size of 4 millimeters. I recognized 10 winged aphids, 2 beetles, 1 leaf hopper and 1 Syrphid fly (7 millimeters long). The remainder were small flies and, possibly, some Hymenoptera.

Knowing the shock of being captured would keep number 036 away from the nest for at least an hour, I held her for a plumage examination. I released the bird at 4:15 p.m. Her failure to reappear and feed by the time I left (6 p.m.) introduced a further complication. At 4:45 p.m. number 561 (036's mate) had surprised me as I stood atop the ladder adjusting the camera—there was little to do except stand motionless and await his reaction. Fifteen minutes later the bird began to approach the nest in characteristic fluttering fashion. The sound of his wings did elicit begging, though I was surprised at its weakness considering the fact that the young had not been fed for 2½ hours. After he had fed one nestling, number 561, being unrelieved by his mate, remained to brood and was still brooding when I departed at 6 p.m.

I watched the birds again from 8:10 to 9:05; their feeding was normal.

I regret the lack of data on how often the parents were bringing food, for July 1 fell on Sunday with its time-consuming church and family obligations. Thus I was unable to get to the nest before 2 p.m. My disturbing the adults undoubtedly was responsible for part of their decreased feeding, yet I feel that it would not have achieved importance had the weather been favorable in the morning at least.

July 2 was a good day for the chimney swifts. It was clear and cool (48 degrees) at dawn. There was a thin cirro-cumulus veil by 11:15 a.m. which broke into a general distribution of cumulus clouds by 12:30. Temperatures rose rapidly, attaining a maximum of 79 degrees at 2 p.m.

By 10:15 that morning all the young were heavier than the day before. Numbers 1 and 2, both of whom weighed a bit over 2 grams more than the previous day, had increased by 25 percent and 30 percent respectively. From 11:15 a.m. to 3:25 p.m. I noted that feedings were averaging one every 39 minutes.

Reference to the graph shows that there was a second sharp reduction in weight increase between July 4 and 6—again because of the weather. It was clear at dawn on July 4, but by 10 a.m. the sunlight was diffused through a high, thin overcast. There were a few brief periods of light to moderate rain between 1:20 and 2:50 p.m., after which it remained threatening and humid. The wind came from the south and varied from 5 to generally between 15 and 30 miles per hour.

At 11:45 a.m. on July 4 each nestling was between 2 and 3 grams heavier than it had been at 2:50 the previous afternoon. Between

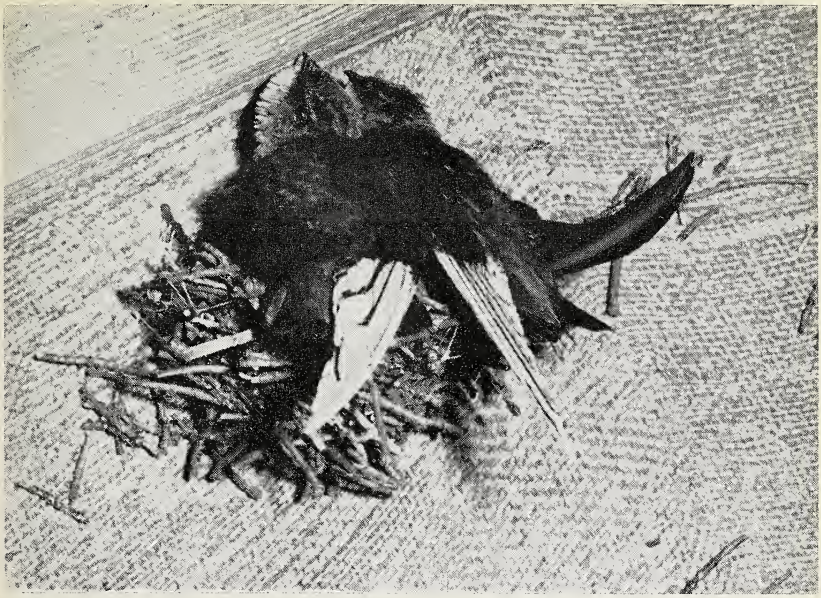


Figure 16. Until the young are 12 days old, both parents brood them at night. As indicated here, the nestlings receive most of their heat from the female, at the left. The male typically covers his mate's right "shoulder." Photographed July 2, 1951.

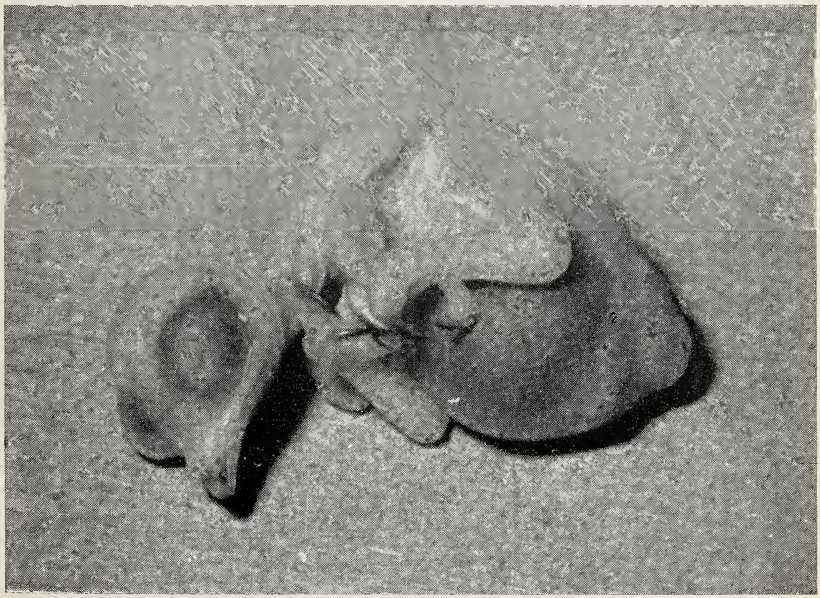


Figure 17. A nestling chimney swift less than 24 hours old. At hatching the bird weighs between 1 and 1.5 grams; it comes from an egg that averages 1.88 grams. Photographed July 4, 1950.

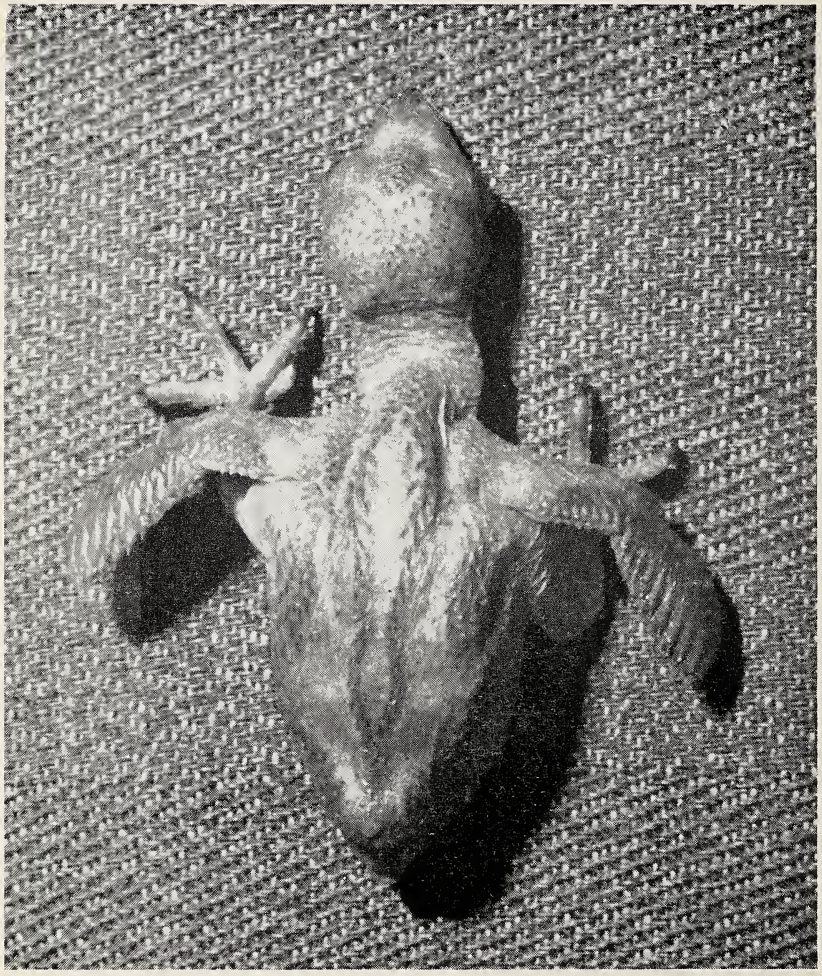


Figure 18. The same nestling on its 6th day. Photographed July 9, 1950.

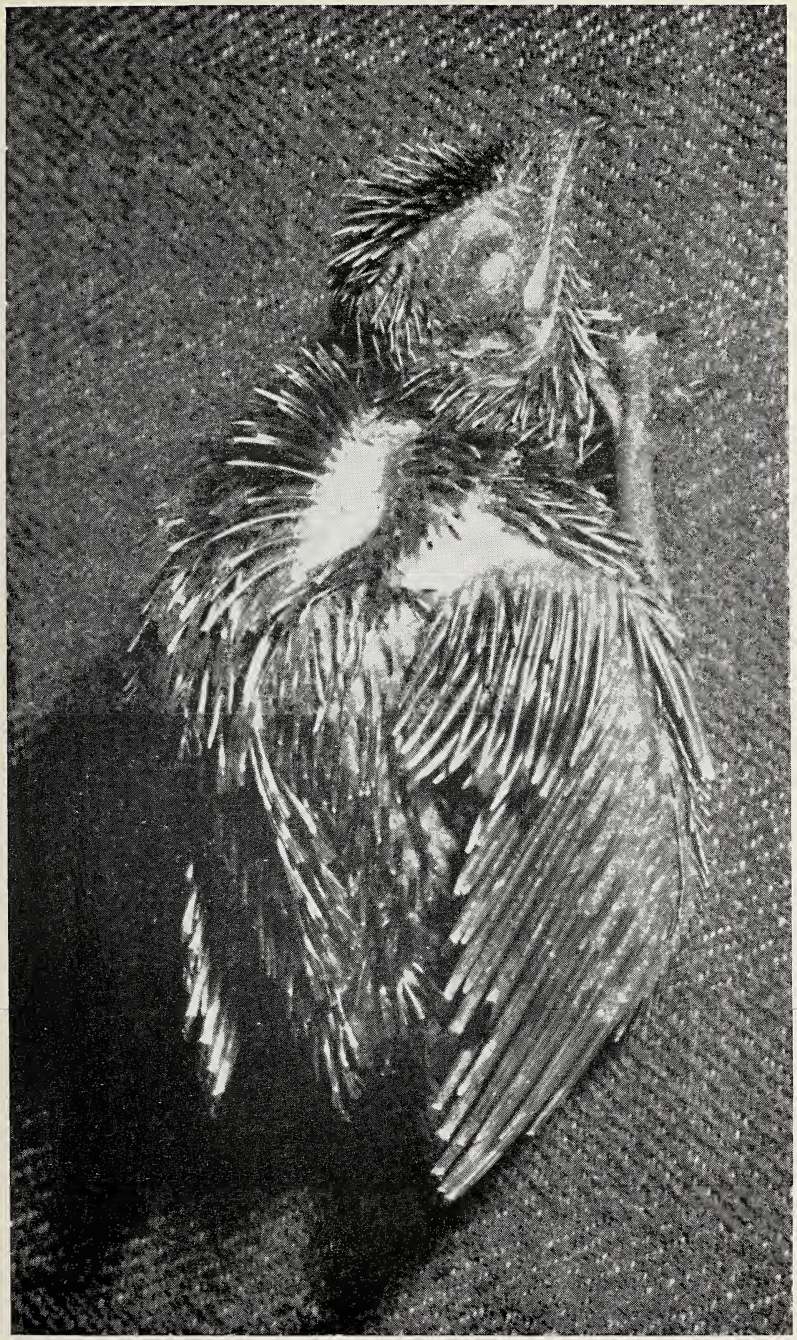


Figure 19. The same nestling on its 12th day. Photographed July 15, 1950.

Figure 20. The same nestling on its 18th day. Photographed July 21, 1950.

Figure 21. The same nestling on its 25th day. Photographed July 28, 1950.

Figure 22. Nest departure (earlier with larger broods) occurred from the 14th to the 19th day. Out of the nest, the young spent much time preening and in practice flights. They roosted in characteristic adult fashion. Photographed July 18, 1951.

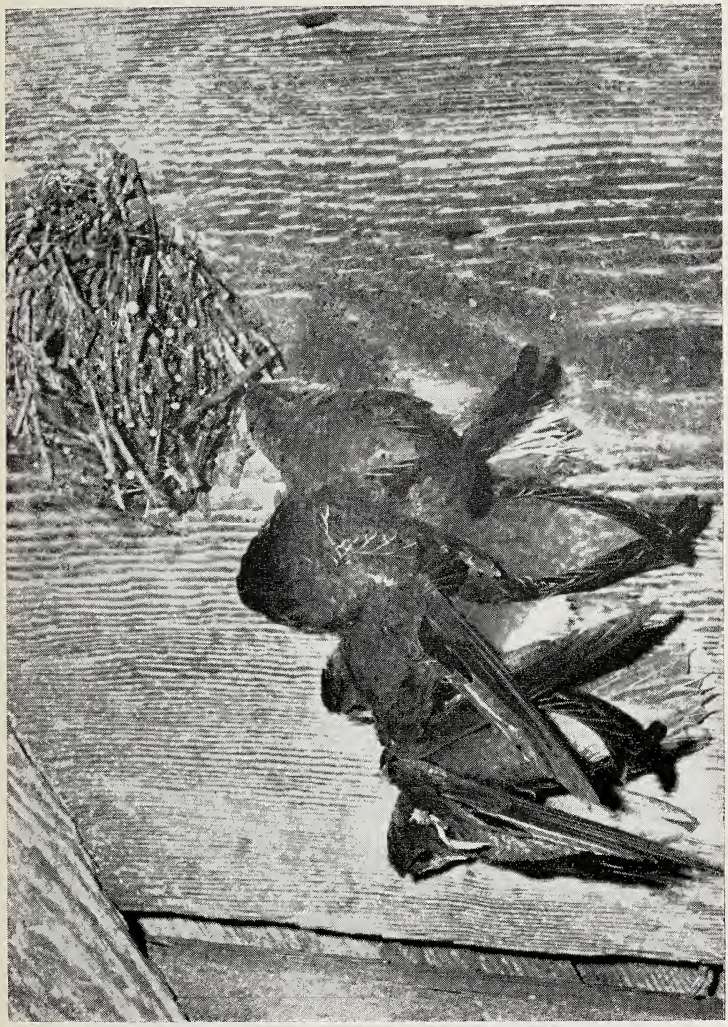


Figure 23. A family of six chimney swifts roosting at night. Soon after the young have made their first flights outdoors the family breaks up and the birds start on their long southward journey to the Amazon rain forest. Photographed August 1, 1950.

11:22 a.m. and 4:05 p.m., July 4, feedings were averaging one per 35 minutes; in this instance, though, averaging them obscures their erratic spacing since there were three intervals of less than 10 minutes each and three of more than 50 minutes each. Nevertheless, the quantity of food the young received must have been small because at 3:45 p.m. two of the young had gained a little weight while the others lost some.

Unfortunately, when the female arrived at 4:05 p.m. to feed I had all the young in the adjoining "room" for banding and weighing. At 4:10 I climbed up to replace the nestlings—I thought I could do it without frightening her—but she flew out and had not returned by 5:46 when the male (who had been brooding) left the barn. As I emerged from the weighing room at 5:55 a swift entered the site but, seeing me, immediately flew out. I mention this not only to indicate that there was an interruption in the feeding sequence, but also to point out that disturbing a chimney swift at its nest has a profound effect quite unlike that which one associates with most passerines.

My notes show that the male fed at 4:21 and 5:25 p.m. I departed at 6 o'clock and was back in the blind at 7:25 p.m.

From 7:45 to 8:33 that evening I witnessed frenzied feeding by the female. She fed 13 times in the 48-minute period, averaging one feeding approximately every 4 minutes. The longest interval between her trips to the nest was 7½ minutes and the shortest was 1½. The male had entered the site at 7:47 but during her activity he merely perched near the nest, occasionally chippering.

I was most interested to learn what the female had been feeding the young, so at 8:41, when it was plain that both birds were in for the night, I blocked their window and climbed to the nest. Two young each had a single Cercopid in its gullet. Now it happened that at 7:25 p.m. (before the female's animated feeding) I had obtained a large pellet from one nestling and single Cercopids from two others.

Examination of the 7:35 p.m. pellet disclosed a variety of insects that averaged 5 millimeters long. One Hemipteron was *Nabis sp.* (Nabidae). Also present were 20 small flies, 12 Mayflies, 4 leaf hoppers, 2 small caddis flies (Trichoptera), 1 Cynipid wasp, and a 7-millimeter fly that most likely was a Sarcophagid.

I weighed the young at 8:50 p.m. and, compared with their weights at 3:45, number 1 had gained 0.7 grams, number 2 had lost 0.8, number 3 had gained 3.5, and number 4 had gained 1.0 grams. The group as a whole had gained 4.1 grams. But in spite

of this increase and the very frequent feeding by the female, I do not believe she was bringing normal-sized pellets to the young for several reasons.

At the time the bird was making so many trips to the nest there was a low, thick overcast with very high humidity. The number of Cercopids she caught was more surprising than the fact that she captured any insects at all. In order for her to get enough food to form pellets, the air would have to be thronging with insects, a situation which I do not believe existed at the time.

Since the insects in a pellet are quite thoroughly tangled and stuck together with saliva, a young swift swallows a pellet in its entirety. The presence of single Cercopids in the youngsters' gullets indicated that the female was feeding one or at most a very few insects at a time.

On each return of the female all the young literally screamed for food—as though they were starving. This was never the case on occasions when I was certain the young were getting food pellets, i. e., full-sized meals.

During my absence from 6 to 7:25 p.m., the parents probably did considerable feeding to account for most of the 4.1 grams increase in the group's weight. Since a food pellet may contain anywhere from 0.2 to 0.9 grams of insects, it would not take many feedings to add up to the increase noted.

There was a slight increase—2.6 grams—in the group's weight on July 5 which was unexpected in view of the irregularity of events and the weather. Since atmospheric conditions are the key to the matter I shall describe them in some detail.

It was overcast at dawn with the thermometer at 62 degrees F. By 6:30 the sky was beginning to break up, blue becoming visible by 9:15 along with fits of sunshine and a light south wind. Wind velocity increased to 15-20 miles per hour by 10:15, the sky was clearer and the sun shone steadily. Twenty minutes later, however, it began to get cloudy again, but when the sky was half clouded over (10:45) it broke up and was sunny with cumulus clouds at 11:15. Wind velocity then exceeded 20 m. p. h., at times probably approaching 30. Half an hour later the sky was overcast, and following a moderate rainfall between 1 and 1:05 p.m., it suddenly cleared. This sort of thing was characteristic of the remainder of the day. Maximum temperature was 71 degrees F. at 12:35 p.m., though generally the mercury was in the low 60's.

One other important factor needs to be mentioned. When I arrived at the barn at 6:13 that morning, the male was already out

getting food. He returned at 6:16 while I was in the weighing room and judging from the begging sounds he fed one of the young. From 6:18 to 7:04 both birds brooded. The female flew out at 7:06. I inadvertently alarmed the male by emerging from the weighing room a minute later, so he departed also. Apparently I frightened him more than I would have guessed, for while I was continuously present from 9:42 a.m. to 5:55 p.m. he never appeared. When I came back at 7:34 p.m. he was perched on the right side of the nest and was still there when I left at 9 p.m. even though his mate had been feeding once each 15 minutes. Therefore, a fact to bear in mind is that almost all the feeding that day was done by the female. Had the male fed, too, I think the group's increase would have been twice what it was. This statement might be taken to mean that it was not the weather that determined how much weight the young gained that day; hence, additional facts should be mentioned.

As stated above, July 5 was a cool day, which necessitated brooding by the female on three occasions between 9:42 a.m. and 5:55 p.m. The periods lasted 25, 48 and 28 minutes respectively. Had it been warmer, the bird could have devoted more time to getting food.

Feeding in the period from 10:50 a.m. to 12:38 p.m. (before any rain had fallen) averaged one each 33 minutes. Three food pellets which I took from the young in that interim were all large, suggesting that just before a rain is a good time for the swift to catch insects. Food-getting was evidently more difficult once the first brief rain occurred, for the female then spent an average of 45 minutes per food-getting trip. The only pellet I took during that period was a medium-sized one obtained at 3:17 p.m. It consisted almost entirely of 35 well digested stone flies (Plecoptera) that measured 6 millimeters or less. The other forms were 3 flies measuring 2, 4 and 7 millimeters; a 5-millimeter Hymenopteron, and a leaf hopper 3 millimeters long. Had the weather been better, the young doubtless would have gained more weight than they did.

July 6 was a good day for the chimney swifts at Beaver Kill. This was evident from their low, leisurely flying and from the fact that they engaged in social flights throughout the afternoon. The weather had cleared during the night; there were cirrocumulus clouds in the morning followed by a typical cumulus sky in the afternoon. The breeze was from the south, varying from 5-10 m. p. h. but generally about 5 m. p. h.

Mrs. Woelfle had been rummaging around in the barn near the swifts' nest in the morning and apparently alarmed the male, so for the second successive day he practically did not feed the young. He did no feeding between 11:10 a.m. and 6:10 p.m.; between 7:28 and 8:58 p.m. he fed only once. Nevertheless, the atmospheric conditions were favorable and the female was responsible for a considerable increase in the weight of the nestlings—9.5 grams for the group.

After the young recovered from the effects of the poor weather and the disturbances to their parents, their weights soared anew as the graph shows.

An unplanned starvation experiment

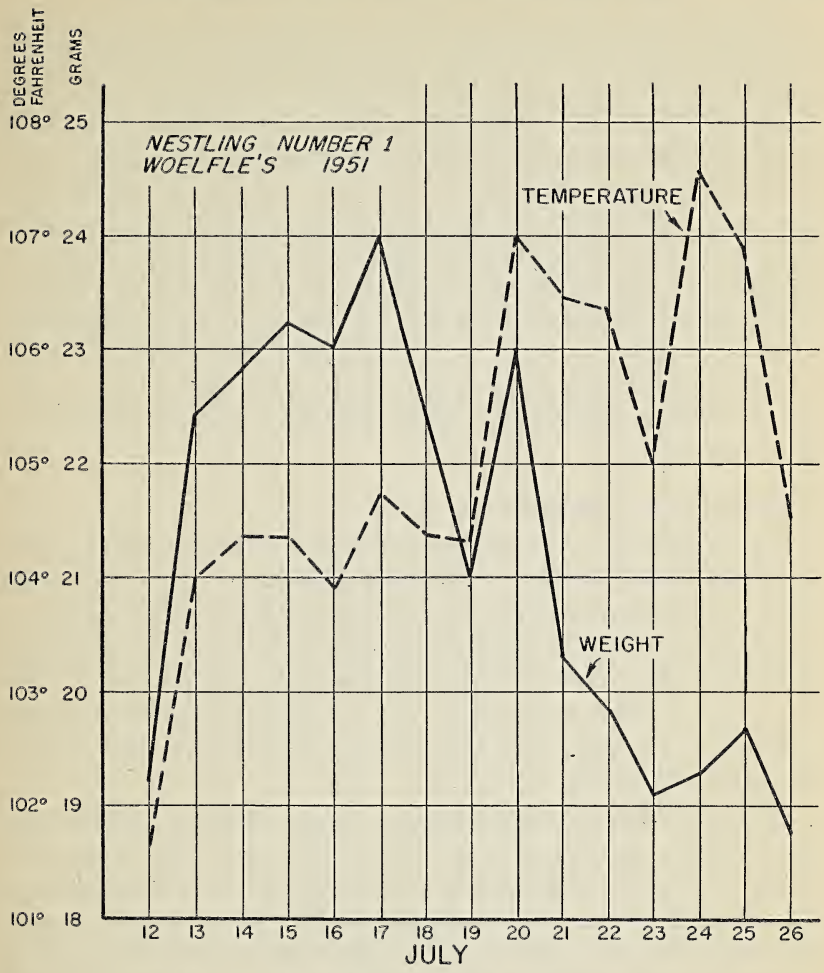
Through numerous experiences with chimney swifts I learned that it was seldom necessary to close their exit when I wished to examine the young after dark. If the youngsters were secured quickly and quietly and the parents were not molested in any way, the old birds would remain high up on the nesting surface. When I wished to study the adults in the hand, I captured them by quietly slipping an insect net over them as they clung to the surface on which the nest was fastened. I took care not to miss on the first try nor to allow an adult to get away once I netted it, for at such times the bird might fly blindly about the building and become difficult to capture. When I wanted to catch the parents, I first blocked their exit as a precautionary measure.

On the night of July 8, 1951, I captured the adults at Tract C but after getting the data I wanted, I forgot to remove the cover from the window. As fortune would have it, I did not visit that nest until 3 p.m. the next day. I was dismayed to discover what I had done. Graph 4 illustrates the effect of the "fast" on the young.

Since a young swift loses between 0.4 and 0.6 grams overnight, the losses shown are not quite as serious as they appear. I spent practically every remaining minute of that day capturing insects and feeding the young all they would accept. Not wishing to disturb the parents unduly, I did not continue the supplementary feeding program on subsequent days. The youngsters did gain weight slowly and by the third day after the mishap they had recovered their losses.

Growth in terms of temperature

There was a close correlation between weight and body temperature (and therefore between temperature and weather) in



Graph 6. Weight and temperature changes in a nestling

the young chimney swifts. This was expected in view of the work of Baldwin and Kendeigh (1932). In the discussion on weight, and weight versus weather, I presented a graph for nestling number 1 from the 1951 Tract C nest; so, I have used the same bird's data in the graph that follows. For comparison, the weight curve is repeated and both the weight and temperature curves are plotted on the same axes. Weight and temperature readings for any particular day were taken at the same time—generally between noon and 3 o'clock. The young swifts were in their 17th day when I began to take body temperatures. The data for number 1's two siblings are substantially the same.

Also in conformity with published material is the fact that temperatures were usually highest in the afternoon. Contrary to expectations, they were not lowest at about midnight. There is an explanation for this divergency. Since body temperature varies with metabolic activity, minimum or standard temperature of a nestling will not be reached until the stimulating effect of its last meal has ceased. In the case of the chimney swift—possibly like few other birds—the last meal (i. e., food pellet) may be retained in the gullet for several hours after being received. If a bird were fed for the last time at 8:30 p.m., for example, and did not swallow the pellet until 10:30, standard temperature might not be reached before 1 or 2 a.m. On July 19, 1952, I took a pellet from a Tract C nestling at 12:45 a.m., four hours after the bird had received it!

Temperature regulation

By carrying out a simple experiment at Tract C on July 13, 1951, I learned something of temperature regulation. I arrived at the barn at 11:45 p.m. and immediately recorded the temperature of number 3. It was 103.6 degrees F. Next I put the bird on a piece of cloth in a small cage and then set it outside for 47 minutes. The outdoor temperature was 53 degrees F. and no air was moving. At the end of the test the bird's temperature had dropped to 101.9 degrees F.

Two nights later I tested this bird again. When I put the swift in the cage at 9:30 p.m. its temperature was 104.5 degrees F. There was no air stirring and the temperature was 63 degrees F. One hour later the swift's temperature had fallen to 103.5 degrees F., while the air temperature had gone down to 61.5 degrees F. After I held the bird snugly in my hand for 10 minutes, its temperature rose to 103.9 degrees F.

On July 17 I did a similar experiment with nestling number 2. At 10:50 p.m., its temperature was 104.9 degrees F. I put the bird in the cage; since it was old enough to roost like an adult, it did not lie on the cloth but clung to the wire mesh. The outdoor temperature was 64 degrees F. and the wind—if there was any—was under 1 mile per hour. In 35 minutes the swift's temperature fell to 104.4 degrees F. Probably temperature regulation was almost fully established in the young by this date.

Opening of the eyes

The young swifts usually opened their eyes on the 15th or 16th day, but sometimes it was as late as the 18th day. They gave

evidence of not being able to see well for the first few days, and during that time the pupils were a milky blue color. Placed on the balance, the birds stared into space and occasionally leapt off the pan still staring into space. A hand passed quickly before their eyes had no effect; at least, the young behaved as though they had not seen it.

At first a swift opened only one eye, and that fitfully. A day or more passed before they really saw things. The progressive opening of the eyes is evident in the photographs that portray the growth of a young swift.

THE YOUNG MOVE OUT OF THE NEST

The stimulus to leave

The time of nest-leaving seemed to be determined by how many young swifts were in a nest. Broods of 4 and 5 outgrew the nests when they were 14 days old and their eyes were just beginning to open. Smaller broods remained in their nests an average of 19 days. Proof that the young left because they were crowded came when I placed young in an enlarged dummy nest. They remained in it up to five more days.

Young that could not see usually left the nests in the morning. As it was cool then, my earlier notion that excessive heat from the siblings prompted their leaving was not valid. Generally only one or two got out of a nest and they clung to the wall immediately above. Sometimes they were barely out of the nests. Young able to see were stimulated to leave when a parent appeared with food and lingered near them. Those that were hungry scrambled toward the adult and, having been fed, remained on the wall. Often, however, they went back, especially to roost for the next few nights. I did not see the young reenter the nest when something alarmed them, as Miss Sherman noted (1952: 55). None of the students of the chimney swift has reported the type of behavior which Bailey (1905: 131) described. He accounted for nest-leaving thus:

> Generally, after feeding the young, the old bird crowded over to one side of the nest and cautiously insinuated its body behind the young birds. The adult bird kept crowding until all but one or two of the brood of five were forced out of the nest and took up positions on the vertical roost. The remaining birds would sometimes leave the nest of their own accord and follow their mates. This was noticed especially after those clinging to the boards had been fed.

Mr. Bailey's paper included a photograph which he said illustrated the act. Actually, the bird appears to be feeding a chick in the nest, while two young below the nest are begging.

Mortality at this stage

It is my opinion that the two weeks between leaving the nest and making the first flight outdoors are the most dangerous in the life of a chimney swift hatched in a building. I recorded only one instance in which a young bird fell out of its nest and died. On the other hand, 11 swifts left the nests but starved to death before they flew outside; this includes an entire brood of four whose mother died a few days after they left the nest. Mortality is high because the young birds, with incompletely developed flight ability, wander into odd corners, far from the usual feeding place which is at or near the nest. A swift thus isolated begs when a parent enters with food, but it is the young that remain where the old birds are in the *habit* of feeding who get the food. In 8 to 10 hours a stray bird shows the effects of undernourishment: body temperature falls with the decreased weight, plumage is no longer smooth but appears ruffled, the bird acts listless, and—worst of all—its begging reflex weakens and ceases. I have found these waifs when they were too starved to beg, and noticed that the swallowing reflex, too, had ceased to function. Although I stuffed them with insects, the birds died with food in their gullets.

Generally, the young swifts remain in a close group on the wall near the vacated nest. Between meals they move to a new area a few inches away, and, when not preening or looking about, they cover one another's backs with their "shoulders"—as the parents do. They beg instantly when a parent comes with food, each looking at the adult. The old bird does not feed in turn, but gives the food pellet to the one that begs hardest. At night the entire family roosts so close together that it is difficult to tell how many birds are included in the mass of feathers.

YOUNG GO OUTSIDE

Age and time of departure

As a rule, young chimney swifts at Beaver Kill took their first flights outdoors on the 30th day after hatching. Miss Sherman (1952: 57) arrived at a similar figure. Widmann (*in* Bendire, 1895: 180) said "the young do not leave the chimney before they

are four weeks old." Also in agreement with the above authors was the fact that my birds did not leave the nest sites all on the same day. Instead, departure extended over as many as three days. Widmann (ibid.) recorded one span of 11 days between departure of the oldest and the youngest swifts in a brood.

Flight was well developed by the time the young departed, for during the two weeks out of the nests the birds had exercised their wings through fluttering in place on the walls, and by taking short flights near the nests. Site departure, in my experience, was restricted to mornings. Miss Sherman observed this, too (1952: 59). Moreau (1942: 47) noted that his white-rumped swifts departed in the morning. This tendency was also true of the common swift (the Lacks, 1952: 210; Cutcliffe, 1951: 50-53). We do not know the behavior of other American swifts in this respect.

Fledging success

Earlier I stated that hatching success at Beaver Kill was 90.7 percent over a 13-year period. Out of 24 nests that involved 86 hatched eggs, 74 of the young survived to fly outdoors, representing a fledging success of 86 percent. No data are available for other American species. Nestling survival did not depend on favorable weather as it did with the Lacks' common swifts. Their figures ran from a low of 39 percent in bad weather to 100 percent when the weather was fine (the Lacks, 1951: 515).

Return to nest sites

The chimney swift differed markedly from the common swift in that the young regularly returned to their nest sites after their initial flights outdoors. (Young Alpine swifts behave like young chimney swifts.) They came back at intervals during the day, presumably to rest, and for the first week (or more) returned each evening to roost with the parents and siblings. The Lacks (1952: 211) supposed that their swifts started migration on the day they left the nests, although Cutcliffe (1951) said that some young common swifts returned to the nests for several days after the first flights.

Cessation of parental care

Once the young had gone outside, I no longer saw the parents feed them. Sometimes an adult entered a nest site while young were present; they begged but did not receive food. Such behavior would seem to be in line with the observations of Miss Sherman,

Widmann, Dexter and others who make no statements to the contrary. One often sees the various swallows feed young on the wing, but there are no camparable published observations for swifts. Moreau wondered if his young swifts received "the aftercare usual in birds, and, if they do, how the parents find them" (1942: 48).

Breakup of the family group

It was easy to recognize families as they flew about in the vicinity of their nest sites. There was much loud, excited group chippering, although it plainly lacked the sharp tone of courtship flights. Adults were well into the postnuptial moult, the missing secondary and primary feathers creating a conspicuous notch in the blade-shaped wings. The birds flew low, usually below treetop level.

A few days after the young ventured outside, the families began to disintegrate. At Beaver Kill this took place in the latter part of August. I recorded young from Tracts C and F in the silo at Tract A, and a Tract A young once visited Tract C. Sometimes only one young strayed away from its nest site, while at other times a parent and several of its young went to a different tract.

Once the young began to wander, I no longer captured them at their own nest sites. The chimney at Tract B was the only structure in the area that bore any resemblance to a community roost. I caught 10 birds there on August 21, 1950, which was a record "take" for me. It included three birds that had bred at the Tract that summer; the remainder were unbanded individuals. Dexter's papers present a similar picture of this post-nesting wandering.

Departure from the study area

During the last week of August the chimney swifts disappeared rapidly from the Beaver Kill study area. The latest observation of birds inside a nest site occurred on September 1, 1952; it was raining hard that afternoon, so the Tract C female and one of her young rested on the rug. It was unusual to see a swift anywhere in the area after September 1. Although I lacked banding recoveries to support my supposition, I presumed they had started on their long leisurely southward journey to the Peruvian rain forest.

SUMMARY

The chimney swift, *Chaetura pelagica* (Linnaeus), occurs over most of eastern North America where there are suitable nesting

places in the form of hollow trees, woodpecker holes in trees or buildings. Since the coming of the white man to North America, this swift has taken to nesting in his buildings, particularly in unused chimneys—hence, its common name.

The investigations on which this account is based were carried on from 1939 to 1953, chiefly in a hamlet known as Beaver Kill, in the Town of Rockland, Sullivan County, New York. Swifts occupied several buildings there and afforded opportunities for close observation. The birds were banded and color-marked for easier identification. Techniques of capture, marking, weighing, obtaining temperatures and photographing the birds are described.

Buildings on seven tracts of land (farms) which were occupied by the swifts are described. The swifts tended to select dark places in the structures for their nests, and they placed them high above the floors. There were no nesting associates.

Returns of banded birds showed that successive annual occupancy of a nest site depended not only on its meeting the swift's modest requirements of darkness and shelter, but also on the return of at least one of the previous year's birds. A site often went unoccupied when both failed to come back.

Weather influences the spring migration and behavior of the birds. The arrival of residents in the study area is considered along with the passage of transients.

This swift, like others in the Family Apodidae, exhibited a strong return instinct. Of 58 adults, 27 (46.6 percent) returned to the study area. Among the 40 adults banded at their nests, 25 (62.6 percent) came back, the majority to their previous sites.

The 92 birds banded as nestlings yielded only 10 returns (10.8 percent), five of which went back to their hatchplaces. Three birds that were not retaken in the summer following birth but were recaptured later support the belief that not all chimney swifts breed in their first summer.

Few chimney swifts live beyond 4 years. The oldest individual at Beaver Kill was 6 years, but other writers have recorded a 13-year old bird, one 12, four 11, and seven 10 years of age.

Much research was done on methods of determining sex in living birds. The chimney swift, like some other species, shows no external morphological characters correlated with sex. Weight and temperature, particularly the latter, seem to be related to sex. Usually both are greater in females than in males. Dissection remains the only certain means of sex determination. On the average a nesting swift weighs 27 grams and has a body temperature of 108 degrees F.

A behavior pattern that appears to be correlated with sex is the female's tendency to cover the eggs and the young at night and her greater attachment to the young. The males seem to scold more than their mates.

Display in the swift family usually occurs in the air at a distance from the nest site and is, therefore, difficult to study. In the chimney swift it is characterized by flying in loose association, trio flying, and finally, when pair-formation has taken place, flying in association (or flying together). There is less display with pairs of swifts that have been mated previously.

Trio flying is the most active phase of display. The three birds fly rapidly at heights greater than 500 feet, utter sharp chips and appear to be playing a game of follow-the-leader. They execute sudden, angular turns like figure skaters on ice.

It is most likely that the three swifts represent two males chasing a female. The males compete with one another for the position behind the leader, but they do not attempt to maintain leadership after gaining it.

Before and after pair-formation chimney swifts engage in a unique kind of coordinated flight called V-ing, in which the birds glide with wings elevated in the shape of a V. Peculiarly, the rear bird or birds initiate V-ing when swifts are flying together, but the leader follows suit even though it may seem to human eyes to be unable to see what has happened behind it. V-ing is best developed in mated swifts and serves to maintain the pair bond.

Copulation has been described for the European common swift, the African white-rumped swift, and our white-throated swift. The chimney swift is thought by most persons to copulate on the wing. The present writer witnessed copulation four times at the nest site. It occurred before and during the brief egg-laying period (never after all the eggs were laid) and was a highly stereotyped activity. The behavior most nearly resembled that described for the common swift.

The nest is a half saucer of dead twigs which both adults snap off, chiefly with their feet, as they fly by. They fasten them to the nest wall with their saliva, and egg-laying commences when the nest is half finished. The birds continue to add sticks, as well as a semicircle of saliva above the nest, until hatching occurs.

In 25 nests in the study area, 10 had 5 eggs, 10 had 4, 4 had 3, and 1 had 2 eggs. There were no sets of 6, although there are records of 6 and more elsewhere.

The same females did not always lay the same numbers of eggs in successive years. The average weight of 22 fresh eggs was 1.88 grams; all weights fell within a range of only 0.3 grams.

Attentive periods were so variable that averaging them obscured their true nature. The shortest complete period was 20 minutes and the longest was 216. This swift resembles the common swift in that the periods do not grow longer as hatching approaches. Since a sitting bird is loathe to leave without being relieved, attentive period lengths are probably determined by the time the partner returns to relieve the mate.

The incubation period at Beaver Kill varied from 19 to 21 days; others have recorded periods from 16 to 21 days. The eggs did not all hatch at the same time. A newborn swift weighed 1.35 grams. Hatching success was high—77 out of 86 eggs (90.7 percent) produced young. Fledging success was 86 percent.

The parents fed by regurgitation during the first week, several young receiving food at a visit. Afterwards, at each visit a parent gave one nestling a pellet of food that, at times, contained more than 200 insects. Small forms predominated, with Diptera heading the list.

An adult fed the young at an average rate of once each half hour for the first week, about once every 45 minutes in the second week, and erratically after that.

The young gained weight rapidly, attaining maximum (equal to adult) weight in three weeks. Weather had a pronounced influence on development in terms of weight and temperature, both of which were closely correlated.

The nest does not become soiled with feces. At first the adults eat the droppings; by the second week, the nestlings defecate over the edge of the nest. The mallophagan *Dennius dubius* was present on every adult and feathered young that I examined, and I found one thrips. I did not find any parasites in the nests, although two species of Cimicidae (*Oeciacus vicarius* and *Cimexopsis nyctalis*) have been reported by other workers.

The time of nest-leaving was determined by brood size; it varied from the 14th to the 19th day of life. The young usually took their first flights outside on the 30th day. They returned to the nest sites occasionally during the day and always at night for a week or more. Then the family group broke up and the birds visited other sites. Most of the Beaver Kill chimney swifts departed for their winter quarters in the Amazon rain forest by September 1.

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By

David P. Stewart
Temporary Geologist

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THE PLEISTOCENE GEOLOGY OF THE WATERTOWN AND SACKETS HARBOR QUADRANGLES, NEW YORK

By

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Temporary Geologist

ABSTRACT

The purpose of this investigation was to map and describe the details of the surface geology of the Watertown and Sackets Harbor Quadrangles and to relate the topography to the glacial processes that formed them. The problem, therefore, was to map the surface forms in detail and to interpret the resulting map and information accumulated during the survey.

During the Pleistocene Epoch, northwestern New York was repeatedly covered by the Laurentide Ice Sheets. In the Watertown and Sackets Harbor Quadrangles, however, the manifestations of earlier stages were destroyed by subsequent glaciation, and, therefore, all of the existing surface materials were probably deposited during the Cary and Mankato substages of the Wisconsin ice episode.

At the beginning of the Cary, and no doubt during earlier advances of the Wisconsin glacier, a segment of the expanding Ontario Ice Lobe in the St. Lawrence Valley invaded the area from the north-northeast. Upon encountering the northern promontory of the Tug Hill Escarpment, the ice was divided into two lobes which moved down either side of this plateau. Later, the advancing ice thickened sufficiently to move over the summit of Tug Hill.

On Tug Hill, the drift is thin, and the bedrock is everywhere apparent near the surface. The Tug Hill drifts north of Sandy Creek are of younger age. They overlie limestones, and the drainage still has an angular pattern due to its recent origin. South of Sandy Creek, the drift is older, is composed chiefly of shales and sandstones and the drainage has had sufficient time to develop a dendritic pattern.

The Black River Valley section of the Ontario Lake Plains is relatively flat because the Trenton beds were planed from over the more resistant Black River Group. South of the Black River Valley, however, the lake plain has an irregular surface expression caused by

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bedrock escarpments resulting from the differential effects of ice erosion on the variable Trenton beds. Since the Trenton limestones are interbedded with shale, glacial erosion was chiefly a matter of planation along layers weakened by shale partings. The results were the carving of steep-sided, steplike terraces, isolated bedrock remnants and deep channels paralleling the ice direction.

Lake Iroquois expanded over the Ontario Basin as the ice receded. Shore phenomena of this episode are found along the slopes of the Tug Hill Escarpment between the Black River and the southern boundary of the area mapped. The highest lake level is marked by a band of washed-off till, consisting of a concentration of residual boulders following the removal of finer sediments by wave action. This high shore now has an elevation of 700 feet at Allendale, rising gently to an elevation of 745 feet east of Watertown. Between Watertown and Adams Center, a gradual lowering of the highest lake level is recorded by beach gravel and ridges. A stable shore, marked by washed-off till, 90 feet below the high water mark, is believed to represent the Lake Frontenac shore.

Between Adams Center and the southern boundary of the area mapped, the high shore is not well marked. Here, a large off-shore bar was built by wave action. The bar is best developed between Adams Center and Adams, its position being over a mile west of the highest lake shore.

The lake plain section of the Watertown and Sackets Harbor Quadrangles has been severely eroded by wave action in many localities. Large areas of bedrock are now exposed, but erratic boulders on the surface attest to the fact that relatively thick accumulations of till once covered them.

Shore features of the fresh water Gilbert Gulf episode in the Ontario Basin are best developed in the extreme southwestern part of the Sackets Harbor Quadrangle. Here, the Gulf shore now follows closely the 300-foot contour. Although evidence in the northern part of the quadrangle is not conclusive, it is believed that the shoreline is nowhere over 100 feet above the present level of Lake Ontario.

INTRODUCTION

The glacial drifts and the related surface deposits of northwestern New York had been surveyed even before the eminent naturalist Louis Agassiz came to the United States and surprised American geologists with his theory of continental glaciation in northern North America. The early copious reports of Hall, Emmons, Mathers and others record and describe the gross features of the glacial deposits. Although their explanations were hampered by a lack of knowledge concerning the Great Ice Age, their writings, nevertheless, did not ignore the existence of these features which were both interesting and confusing to them.

After a partial acceptance of the glacial theory as proposed by Agassiz, the geologists concerned with New York and adjacent areas began to apply these principles in their considerations of the surface features. By 1890, the studies of such notables as Lyell, Chapman, Fleming, Whittlesey, Newberry and Claypool had recognized and correctly interpreted the evidences of multiple glaciation, the glacial lakes of the Great Lakes region, and the sea invasion of the Champlain and St. Lawrence lowlands. In the 1890's the glacial history of New York and adjacent areas was the subject of many studies by interested geologists, including the works of Spencer, Gilbert, Upham, Woodward, Leverett, Taylor and Fairchild.

It is interesting to note that by 1920 the Pleistocene history of the northeastern part of the United States and the adjoining sections of Canada was well established in its general concept, and many isolated features had been mapped in detail. Regional investigations of the glacial deposits in New York State, however, had been accomplished only in a general way, and interest in detailed mapping on an extensive scale remained inactive until recently.

During the past five years, E. B. Owen of the Ontario Geological Survey has started a detailed study of surface materials in the area of Ontario immediately north of the St. Lawrence River (Owen, 1951 and 1953). In New York, Paul MacClintock (1953) has begun a survey on the south side of the St. Lawrence similar to that undertaken by Owen. It was in accord with the studies of Owen and MacClintock that the present problem in the Watertown and Sackets Harbor Quadrangles was undertaken.

Location

The Watertown and Sackets Harbor Quadrangles are located in the northwestern part of the State of New York. The area borders the eastern shore of Lake Ontario and extends inland (east) approxi-

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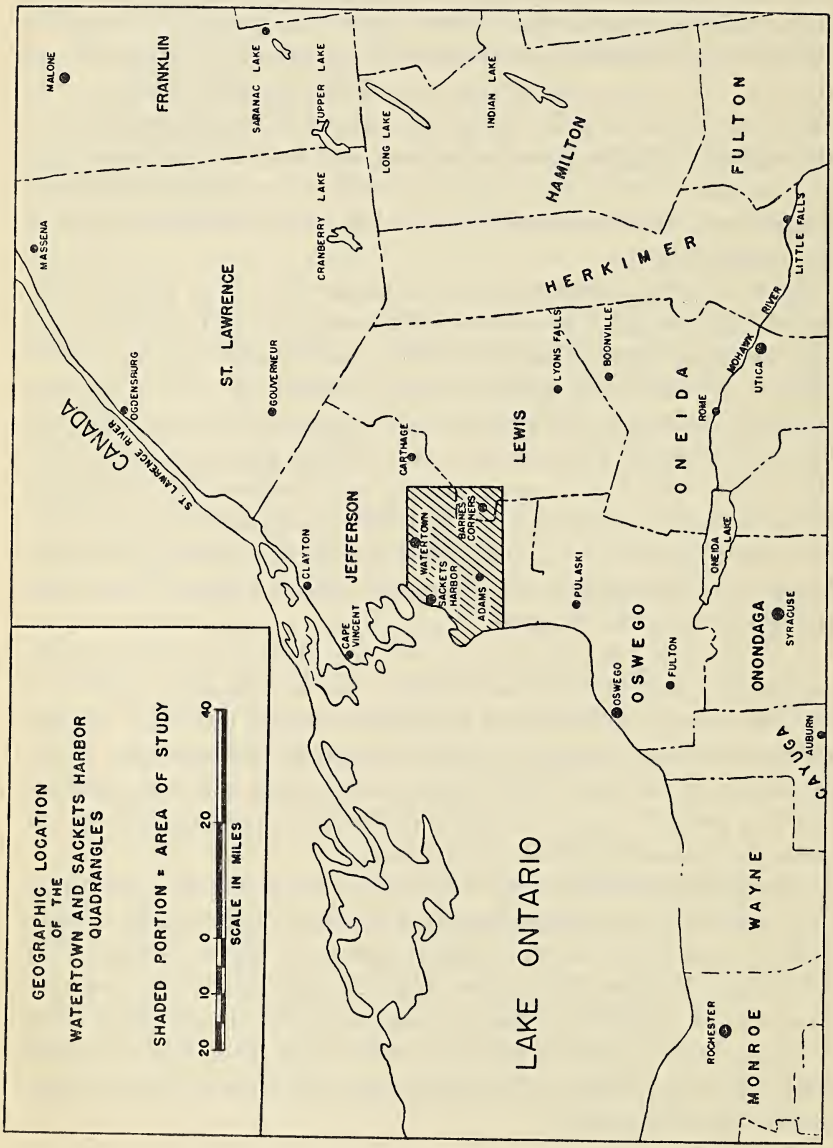
GEOGRAPHIC LOCATION
OF THE
WATERTOWN AND SACKETS HARBOR
QUADRANGLES
SHADED PORTION = AREA OF STUDY
SCALE IN MILES
20 10 0 20 40
CANADA
ST. LAWRENCE RIVER
MALONE
FRANKLIN
MASSENA
OGDENSBURG
ST. LAWRENCE
GOUVERNEUR
SARANAC LAKE
UPPER LAKE
LONG LAKE
CRANBERRY LAKE
INDIAN LAKE
HAMILTON
HERKIMER
FULTON
LITTLE FALLS
MOHAWK RIVER
UTICA
LYONS FALLS
BOONVILLE
ROME
ONEIDA
LEWIS
CARTHAGE
WATERTOWN
SACKETS HARBOR
BARNES CORNERS
ADAMS
JEFFERSON
CLAYTON
CAPE VINCENT
PULASKI
ONEIDA LAKE
OSWEGO
FULTON
SYRACUSE
ONONDAGA
CAYUGA
AUBURN
LAKE ONTARIO
ROCHESTER
MONROE
WAYNE

Figure 2

mately 27 miles from Sackets Harbor. The Black River follows closely the northern boundary and extends southward into the Watertown Quadrangle about 1½ miles at Watertown. The northwestern corner of the area is approximately 12 miles south of Cape Vincent on the St. Lawrence River (figure 2). The whole area, except the southeast corner, lies within the limits of Jefferson County, but a small portion of Lewis County extends into the Barnes Corner section (figure 1). The two quadrangles contain an area of approximately 450 square miles and lie between latitudes 43° 45′ and 44° 00′ and longitudes 76° 00′ and 76° 30′.

Purpose of Study

The purpose of the study on which this report is based was to map and describe the details of the surface geology of the Watertown and Sackets Harbor Quadrangles and to relate the topographic expression to the glacial processes that formed them. To the writer's knowledge, the area had never been previously mapped as a unit, although several prior studies have investigated specific geologic features included in it. The map constructed from the data collected in this survey (figure 1) is contained in the jacket at the end of this report. The map is an essential part of the study, its objective being to furnish a better and more complete knowledge of the Pleistocene history of the region. This report is an interpretation of the surface forms mapped and the information accumulated during this survey.

ACKNOWLEDGMENT

The fieldwork for this survey was completed during the summer and fall of 1953. The work was partly financed by a student honorarium which was awarded the writer by the New York State Science Service. The problem was carried out under the joint supervision of Dr. Earl T. Apfel, chairman of the Department of Geology, Syracuse University, and Dr. John G. Broughton, State Geologist. The writer is grateful for the aid of the New York State Science Service that made the fieldwork possible and is indebted to Dr. Apfel and Dr. Broughton for their supervision, counsel and encouragement during the preparation of this report. The writer also wishes to express his appreciation to Dr. Raymond E. Janssen, head of the Department of Geology, Marshall College, for his criticisms and suggestions for improving the manuscript.

THE SURFACE GEOLOGY

The objectives of the investigation which resulted in this report, as previously stated, involved the detailed mapping of the two quad-

rangles here described. To facilitate the mapping of the detail, the newer, larger scale, 7½-minute quadrangles were used as base maps for the survey. There are eight such maps (7½-minute) included in the two 15-minute quadrangles, (Watertown and Sackets Harbor) about which this report is concerned, but, to avoid confusion in this report, only the names of the 15-minute quadrangles are used.

During the fieldwork, efforts were made to investigate all sections of the area of study. This was necessary to distinguish among the various types of materials and structures and to make possible the marking of the boundaries between the different features thus differentiated.

Since details are many times unpredictable and often more complicated in one area than in another, it was impractical to use any predetermined map legend or descriptive terminology. The symbols of connotation evolved from extensive studies of the surface forms, and new designations were used as necessary to describe them adequately. Inasmuch as the area proved to have a great number of different types of surface deposits, together with several combinations of these types, the resulting map contains a relatively lengthy legend. To aid the reader in interpreting the surface geology as symbolized on the map, the following discussion of the material and structural classifications employed is here presented.

Bedrock

Large areas of bedrock are exposed in the Watertown and Sackets Harbor Quadrangles. These exposures are explainable by the thinness of the glacial deposits, the steep slopes in many areas, or the erosive action of waves on the lake plain during the lake episodes. It was necessary to map bedrock exposures to establish better the significance of the factors or conditions which caused them. Although not originally anticipated, it was necessary to make a rather extensive study of the stratigraphy of the area of study to explain adequately the topography, the character and composition of the drift and the movement of the glacier. The mapping of the bedrock exposures therefore proved to be of much greater value in the determination of the glacial history than is ordinarily expected.

Morainic Topography

The areas mapped as morainic topography are covered with till and have a surface expression that is undulating to rough. Under different conditions such topography would be described as either terminal or recessional moraines. In the area of this study, however, the glacial deposits are very thin, no definite trends can be established for the

morainic accumulations and it is impossible to separate definite markers indicating halts during the retreat of the ice. It is apparent that the ice stagnated over most of the area and did not diminish in stages of active retreat. For these reasons, it would have been misleading to have employed the commonly used designations, and therefore all till with topography more irregular than undulating was mapped under the connotation of morainic topography.

Drumlins

Drumlins are composed of till, have definite topographic expression, and could therefore be included in the definition of morainic topography as stated above. The use of a separate designation for these features was deemed advisable, however, because their elongate direction is a most useful phenomenon in determining the movement of the ice. The boundaries of the drumlins were therefore marked and a special symbol was employed to show them on the surface map. In areas where the drumlins rise from surrounding till, the boundary was marked at the base of their slopes, but in cases where kamic moraines lap upon the sides of the drumlins, the contact between the gravel and the till was used to mark the boundary.

Ground Moraine

In a very general interpretation of the term, morainic topography could also include ground moraine. It is often useful, however, to distinguish till areas that were deposited under the advancing ice, and it is always appropriate to differentiate between areas of till with little or no relief and those with definite topographic form.

In this investigation, the term ground moraine was used to indicate till surfaces with expressions that were subdued and could be described as level to undulating. Such areas were not common on the Tug Hill Plateau and no significant conclusions could be drawn from their distribution or pattern.

The interpretive values of areas mapped as ground moraine on the lake plain were minimized by the activities of glacial lakes. Since many till areas on the lake plain have been leveled by wave action and it was impossible to differentiate these surfaces from those that were deposited subglacially, this designation could only be used to indicate a level to undulating surface. It is therefore impossible to assume subglacial deposition for areas mapped as ground moraine on the lake plains.

Kamic Moraine

Whereas morainic topography connotes till, the term kamic moraine indicates gravel. The significance of this feature is that it conveys the

idea of a great deal of water activity associated with glacial deposition. In most cases, the structures in the kame gravel definitely indicate deposition in contact with ice. The frequency, size and distribution of kamic moraines in this area substantiate the conclusion that the ice was thin and periods of stagnation were frequent, and the possibility of complete removal of the ice by stagnation is quite definite.

Outwash

The term outwash, or outwash plain, indicates areas of gravel that have a more or less level surface. The significance of these deposits lies in the fact that the material was carried out beyond the terminus of a melting ice margin. The gravel is usually crudely sorted, and the surface is generally level but it is often pitted with depressions formed by the melting of ice blocks that were buried in it. The most surprising fact concerning outwash in the area of this survey is its almost complete absence from the Tug Hill section. This again indicates no recessional halts in the retreat of the ice.

Kame Terrace

Kame terraces are gravel accumulations along rather steep slopes, usually of a valley, where deposition by water occurred between the slopes and the sides of the glacier. The gravel is commonly well sorted and ice contact structures are found where the terraces are well developed. These features are particularly useful in distinguishing glaciated valleys.

Lakeshore Phenomena

In an effort to understand better the glacial lakes history in the Ontario Basin, much time was spent identifying and mapping the different manifestations of lakeshore activities. The areas designated washed-off till, marks a shore feature that was formed by wave action. Washed-off till is a boulder pavement caused by the removal of finer materials leaving a concentration of boulders. These features had not been mapped prior to the time of this survey.

Wave action along the shore of a lake often produces beach gravel composed of rock fragments that are rounded by waves at the waters edge. When this material is concentrated at the shoreline a beach ridge is formed. Offshore bars are formed when gravel is removed from the shore area and carried seaward and deposited in a ridge offshore. The gravel ridges in the Watertown-Adams section have been studied by former investigators, but the offshore bars had never before been distinguished from the beach ridges.

Lake Sediments

Since the Lake Iroquois shore deposits follow the Tug Hill Escarpment in the area of this study, many sections of the Ontario Lake Plain are covered by relatively thick deposits of lake sediments. It was not feasible to distinguish between lake deposits that were predominantly composed of silt and those that were chiefly clay and therefore a single symbol is used on the surface map to designate these two very similar materials. In some areas, however, lake sediments in which sand is the chief constituent occur and these areas are designated on the map by a separate legend.

In many sections, lake sediments form a veneer on the surface that is too thin to mask completely the characteristics of the underlying structure. In most of these areas, the material comprising the structures was visible on the surface. But, in other localities where the underlying material was completely concealed, the structure could frequently be determined by excavations which extended through the lake deposit or by the topography. Because of those conditions, the writer believed it would be more informative to map these areas by the use of symbols that would indicate the structure and material of the forms covered in addition to the material covering them. Therefore, symbols indicating lacustrine deposits covering morainic topography, ground moraines, kamic moraines and outwash plains were employed in constructing the surface map.

Dune Sand

Sand deposits formed by the action of winds are commonly associated with lakeshore phenomena. In the Watertown and Sackets Harbor Quadrangles, sand dunes were found which are closely allied with the present shore of Lake Ontario, and also those which correlate with the Iroquois and Frontenac stages of the glacial lakes history. In most of the dune areas along the shore of Lake Ontario, wind action is still active and the sands are periodically shifted from place to place. In the older dune sections, however, the dunes are mostly dormant and ablation by the wind is no longer affective.

In some localities where lake sediments that are predominantly composed of sand are found, the wind is constantly shifting the sand back and forth across the surface. This causes very active migratory dunes to be formed, and patches of lacustrine sand are exposed from time to time. It would have been confusing to have mapped these sandy regions as either lake sediments or dune sand since the conditions are constantly changing. To describe them better, a symbol connoting dune sand covering sandy lake sediments is used on the

surface map to indicate sections where such unpredictable conditions exist.

The above paragraphs emphasize the fact that detailed mapping requires a wide variety of designations to picture accurately the surface geology. To have simplified the mapping by combining or deleting any of these descriptive indexes would have destroyed the effectiveness of the detail.

PHYSIOGRAPHY

The area of study incorporates small portions of two great physiographic provinces of North America, the Central Lowland Province (Fenneman, 1938, p. 449) and the Appalachian Plateau (Miller, 1914, p. 21). The Tug Hill Plateau (figure 3), which extends to the Black River just east of Watertown, is the northern most extension of the Appalachian Plateau Province. The area to the west of Tug Hill, which constitutes a part of the Erie-Ontario Lake Plain Section of the Interior Lowlands Province, is subdivided in this report into the Black River Valley and Eastern Ontario Hills (figure 3).

The Tug Hill Plateau

The Tug Hill Plateau, says Miller (1914, p. 21), is worthy of recognition as a distinct physiographic unit. The area is distinctly a plateau in the strictest sense inasmuch as it is comparatively high, of considerable extent and has a relatively level summit. It rises abruptly from the Mohawk Valley on the south, the Black River on the east and north and the Ontario Lake Plain on the west (plate I, figure 2). The highest point on the plateau, six miles west-northwest of Lyons Falls, is almost 2,200 feet in altitude, but its greatest area, known as the central portion, averages about 1,800 feet. In general, the summit is very flat and swampy (Miller, 1917, p. 19). According to Fenneman (1938, p. 327), the Schooley Peneplain was continuous across this region and the Tug Hill Plateau rises essentially to the level of this upraised plain.

Most geologists agree that the Tug Hill Plateau is an erosional remnant of the plateau area that lies to the south of it. The southern portion has been designated the Southwestern Plateau, and it forms the northern margin of the Appalachians south of Lake Ontario. It is believed that the upraised peneplain, and thus the northern part of the Appalachian Plateau, at one time extended across the whole area that is now central and northwestern New York State.

In the area of this report, the northern end of the Tug Hill Escarpment rises from the Black River and the lake plain (plate II, figure I) in abrupt steplike terraces to elevations, along the plateau rim, of 700

Plate I

Figure 1. Trenton limestone escarpment along the Lake Ontario shore. Picture taken looking east toward Henderson Harbor from the west shore of Henderson Bay.

Figure 2. Trenton limestone escarpment on the slopes of the Tug Hill Plateau, two miles south of Watertown Center

Plate II

Figure 1. Tug Hill Plateau escarpment. Picture taken looking east from the lake plain, three miles west of Watertown Center.

Figure 2. The Ontario Lake Plain, looking west across the Plain from the Dry Hill section of Tug Hill, two miles south of Watertown Center

to 800 feet. The summit rises very gently from the marginal area to over 1,600 feet in the southeastern corner of the Watertown Quadrangle.

The rock strata, although closely associated with the complex Adirondack structure to the west, have never been greatly disturbed. The layers dip gently to the westward, away from the Adirondack Mountains (Miller, 1917, p. 19).

Although the summit of the plateau is described as remarkably flat, that portion of it studied in this survey is deeply incised by many valleys. These channels, which in most cases can be described as canyons or gulfs (Emmons, 1842, p. 408), have been carved by stream and glacial action. They will be given more detailed consideration later in this report.

The Black River Valley

The postglacial (Fairchild, 1910, p. 144) Black River Valley skirts the northern border of the Watertown and Sackets Harbor Quadrangles. The river channel is entrenched in the Lowville and Chaumont formations of the Black River Group. The valley subdivision is limited on the south by the abrupt rise of the beds of the Trenton Group separating it from the flat surface of the Chaumont Formation along the river (figures 3 and 5). Although this subdivision is represented only by a narrow strip along the Black River, its contrast with the Tug Hill Cuesta and the Trenton Escarpment is too conspicuous to be ignored. The limestone strata in the valley dip gently westward and southward away from the Adirondack Mountains and the Frontenac Arch (Young, 1943, p. 144).

The Eastern Ontario Hills

The name, Eastern Ontario Hills (figure 3), originated in the Department of Geography at Syracuse University to describe that section of the Ontario Lake Plain at the eastern end of Lake Ontario (plate II, figure 2). The writer has chosen to use this designation because it best describes this part of the Erie-Ontario Section. Although the surface of this region is covered by Iroquois lake sediments and is commonly referred to as the Lake Plain, it is definitely not a plain. Whereas the advancing Pleistocene ice planed off the Black River limestones to the north, the Trenton beds to the south were grooved, broken and terraced by the glacial action.

The surface of the northern part of the Ontario Hills is more closely related to the Tug Hill area than it is to the lake plain farther south. The surface is quite rough due to terraces, channels and buttelike remnants carved out of the variable Trenton beds.

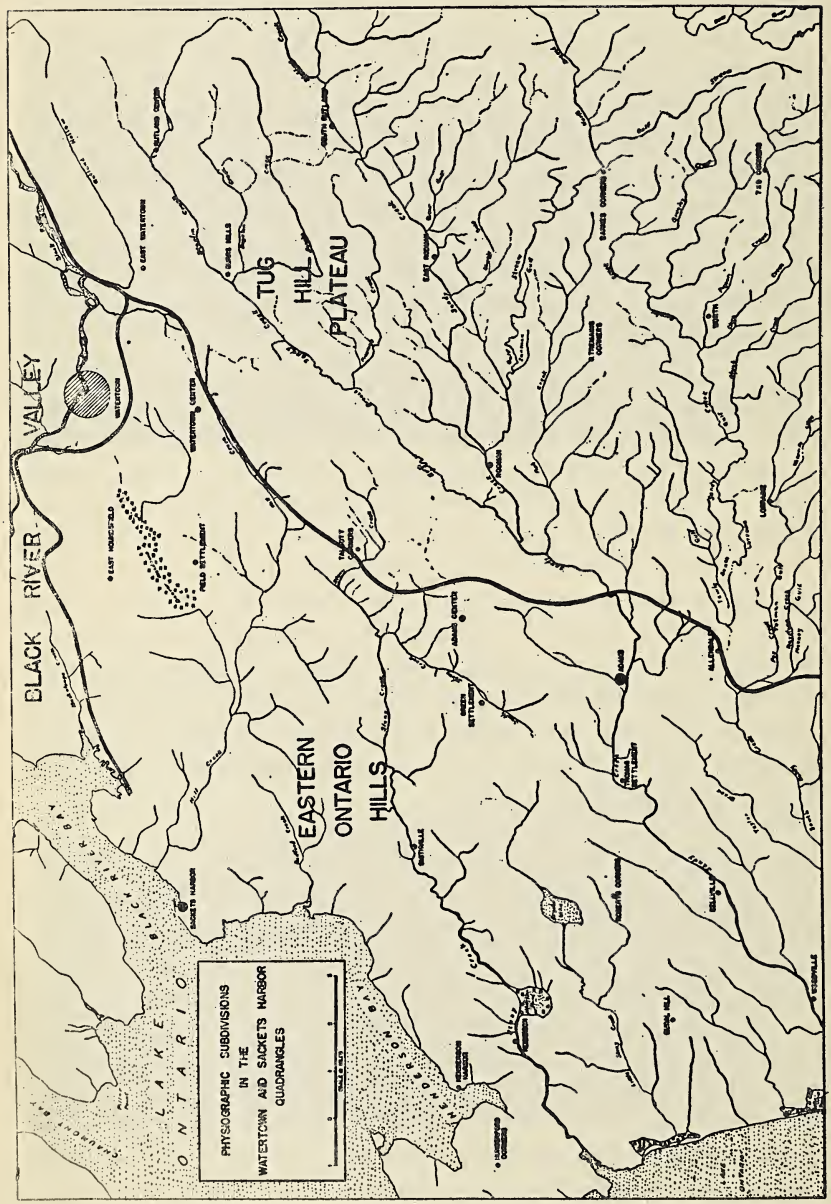
BLACK RIVER VALLEY
TUG HILL PLATEAU
EASTERN ONTARIO HILLS
LAKE ONTARIO
PHYSIOGRAPHIC SUBDIVISIONS IN THE WATERTOWN AND SACKETS HARBOR QUADRANGLES
WATERTOWN
SACKETS HARBOR
ADAMS CENTER
ADAMS
ALEXANDRIA BAY
CLAYTON
THOUSAND ISLANDS
MILES

Figure 3

The Ontario Hills in the southern part of the area mapped are less rugged than the northern part since the bedrock was not so severely affected by the glacier. The hills to the south are constructional, formed by glacial activity, and take the forms of moraines, drumlins and kames. In general, the structure is simple. There is a regional dip of one or two degrees toward Lake Ontario and a slight southerly dip that diminishes southward.

BEDROCK

It was not originally intended that this investigation should be concerned with the bedrock in the area of study. The purpose of the survey, as already stated, was to make a detailed study of the deposits which relate to the Pleistocene history. As the mapping progressed, however, it became more and more apparent that the topographic expression as well as the character and composition of the drift were so closely related to the underlying rocks that a consideration of the physical characteristics and distribution of the various lithologic groups became necessary. For this reason, a brief discussion of the lithology of the stratigraphic units is here presented.

The generalized section of the sequence of strata tabulated in figure 4 has been modified after Kay (1933 and 1937), Young (1943), Ruedemann (1925) and Goldring (1931). It should be noted that for the purpose of stressing the lithology the classification of Goldring (1931) of the Lorraine and Utica shales has been used rather than the more recent separation made by Kay (1933, p. 2). These modifications will be clarified in the discussion which follows.

The entire section in the area here described is Ordovician in age. The Middle Ordovician Mohawkian Series, which includes the predominantly limestone Black River and Trenton groups, comprises the lower and more widely distributed part of the sequence. The shales of the Cincinnatian Series of Late Ordovician age, which compose the upper part of the section, are limited to the southern part of the Watertown Quadrangle (figure 5).

The Black River Group

The Black River Group includes the Pamelia, Lowville and Chaumont limestone formations. The Pamelia, however, does not outcrop in the area of this study, and therefore the Lowville is the oldest exposed formation. In this region, the Lowville is a fine-grained, dove limestone that has a characteristic gray color when weathered (Goldring, 1931, p. 281). This is the Birdseye of Emmons (1842, p. 382), so named because of its characteristic appearance due to worm tubes within it that have been filled with clear calcite. In the Sackets Harbor

GENERALIZED GEOLOGIC SECTION
WATERTOWN AND SACKETS HARBOR QUADRANGLES
(CLASSIFICATION BASED ON LITHOLOGY)

LOWER PALEOZIC ERA	ORDIVICIAN SYSTEM	CINCINNATIAN SERIES	LORRAINE GROUP	PULASKI	300 Feet -- Grey shales alternating with sandstone beds. Sandstone calcareous layers and sometimes more than a foot in thickness. Predominantly non-calcareous sandstone at the top.
				FRANKFORT	200 Feet -- Black and grey argillaceous shales. More grey than the Utica. Interbedded grey, thin sandstone beds.
			UTICA SHALE		75 Feet -- Black, fine-textured, thin-bedded shale with zones of much quartz. Jointed -- [Same as DEER RIVER of Ruedemann. Correlated with COLLINGWOOD (Upper Trenton) by Kay].
		MOHAWKIAN SERIES	TRENTON GROUP	COBOURG	150 Feet -- Argillaceous, buff weathering limestone in top of section. Massive resistant limestone in middle. Shaly limestone at base.
				SHOREHAM	175 feet -- Very shaly. Dark calcareous shale interbedded with coarse textured limestone beds.
				HULL	100 Feet -- Bluish grey, coarse-textured, thick-bedded shaly limestone. Upper part very resistant.
				ROCKLAND	60 Feet -- Heavy-bedded, dark grey to black, fine-grained limestone at base. Thin-bedded light grey, limestone with shale partings above lower 4 to 6 feet.
			BLACK RIVER GROUP	CHAUMONT	25 Feet - Massive, fine-grained, semi-crystalline limestone. Cherty in some zones. Petroliferous at top.
				LOWVILLE	60 Feet -- Fine grained dove limestone, Weathers to Aspen Grey.

MODIFIED AFTER GOLDRING, RUEDEMANN, KAY AND YOUNG

Figure 4

and Watertown Quadrangles, the Lowville outcrops are restricted to the channel of the Black River.

The Chaumont Formation, overlying the Lowville, is composed of two members, the Leray and the Watertown limestones. These are difficult to distinguish in the field inasmuch as both are dark gray to black, fine-textured, semicrystalline limestones with hackly fractures. The upper part of the Watertown member is said to be petroliferous (Young, 1943, p. 210). The Chaumont forms the rim of the Black River channel and underlies the thin sediments on either side of the river.

For the purpose of this report, it suffices to point out that because of their semicrystalline, fine-grained, somewhat massive characteristics, the limestones of the Black River Group are very resistant. They have not, therefore, been as greatly affected by glacial and postglacial erosion as have other stratigraphic units of this area.

The Trenton Group

The Trenton Group is very fossiliferous and is predominantly composed of limestone layers with alternating beds of calcareous shales of about equal thickness (Goldring, 1931, p. 285). The maximum thickness in the Watertown area is approximately 500 feet.

The Rockland Formation at the base of the Trenton is described by Kay (1937, p. 251) as having a basal member composed of dark gray to black, heavy-bedded limestone. However, this massive unit at the bottom of the formation is only about four feet thick, and the remainder of the section is predominantly a thin-bedded, light gray limestone with shale partings.

The Kirkfield Formation differs lithologically from the underlying Rockland in being thick-bedded and coarse-textured. These beds also have shale partings, but they are not so closely spaced as those of the underlying unit. Because the uppermost member of this formation is more resistant than the overlying Shoreham Formation, the top of the Kirkfield is usually conspicuously terraced or causes waterfalls where exposed in the streams (Kay, 1937, p. 263). The Shoreham is the least resistant unit of the Trenton.

Above the Shoreham and forming the top of the limestone sequence in the Black River area is the resistant Cobourg limestone. It is generally a coarse-textured, thick-bedded unit, but its top is commonly argillaceous with buff-weathering beds.

Because of the interbedded shale layers, the Trenton beds are generally more susceptible to erosion than the Black River limestones.

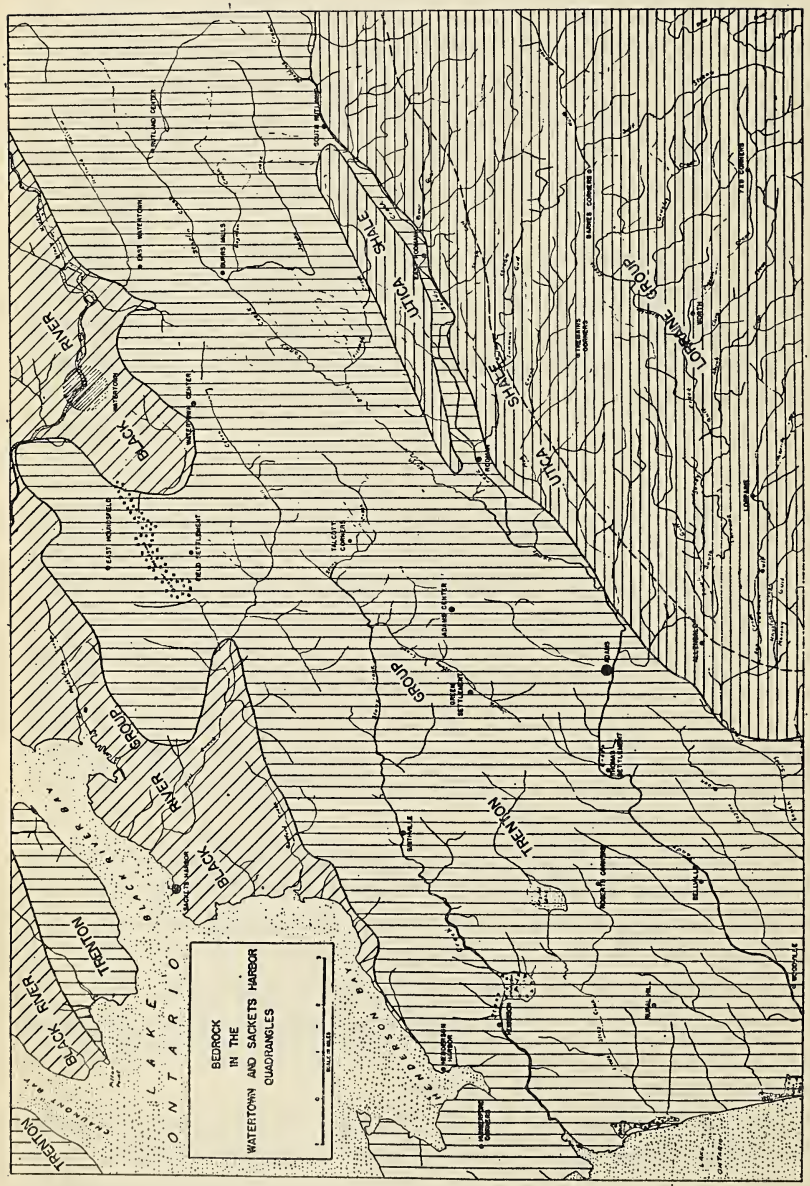
BEDROCK
IN THE
WATERTOWN AND SACKETS HARBOR
QUADRANGLES
ONTARIO
TRENTON
BLACK RIVER
TRENTON
BLACK RIVER GROUP
UTICA SHALE
LORRAINE GROUP
TRENTON
UTICA SHALE
BLACK RIVER GROUP
TRENTON
BLACK RIVER

Figure 5

Because some members of the Trenton are quite resistant, however, the Trenton escarpments rise from the Black River Valley and Lake Ontario in steplike terraces (plate I, figures 1 and 2).

The Utica Shale

The shale beds here described as the Utica are those so called by Vanuxem (1842, p. 56). They were called the Deer River layers by Ruedemann (1925, p. 148) and Kay (1937, p. 284). Kay, however, correlated these with his Collingwood and Gloucester formations at the top of the Trenton Group. The chief difference between the two classifications is the assignment of the Utica to the Mohawkian Series by Kay as contrasted to the position that Ruedemann and Goldring gave it at the base of the Cincinnatian.

The Utica (Deer River) shales form the canyon walls along Sandy Creek between Rodman and South Rutland. They are black in color, thin-bedded, fine-textured and contain a high percentage of sand. In the Sandy Creek Valley, they show an excellent system of joints consisting of two sets. Emmons (1842, p. 398) measured these at 60° and 120°. The Utica exposure in the area of this survey is quite narrow and is nowhere more than two or three miles in width.

The top of the Utica, as here used, includes the Atwater Creek of Ruedemann (1925, p. 148), the Gloucester of Kay (1937, p. 243). This unit is transitional between the lower shaly Deer River beds and the overlying more sandy Lorraine Group.

The Lorraine Group

The Lorraine Group, which includes the Frankfort and Pulaski formations and the overlying Oswego sandstone, according to Goldring (1931, pp. 289-291), constitute the top of the Cincinnatian Series. These layers form the bedrock in the area of study south of Sandy Creek (figure 5).

The Frankfort Formation is the same as that called the Whetstone Gulf by Ruedemann (1925, p. 148). The beds are gray to black in color, but usually lighter than the Utica, quite argillaceous and include interbedded layers of light gray sandstone. In the field, this unit is difficult to distinguish from those above and below it.

The Pulaski shales, at the top of the section in the area mapped, are predominantly grey shales alternating with sandstone beds. The sandstone layers are often calcareous, have a rusty brown weathering habit, and are sometimes a foot or more in thickness (Goldring, 1931, p. 291). In the upper part of this formation, gray noncalcareous sandstones take predominance over the shale. The Pulaski outcrops only in the extreme southeastern part of the Watertown Quadrangle.

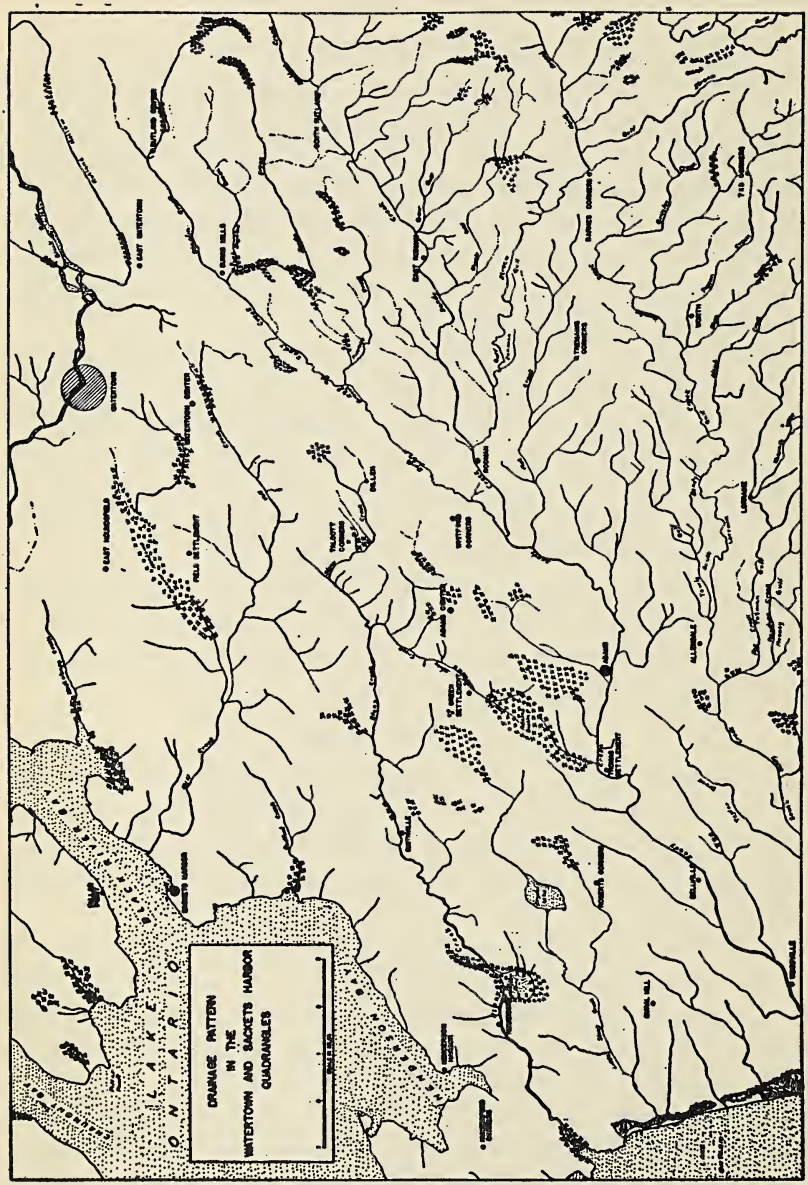
DRAINAGE PATTERN
IN THE
WATERTOWN AND SACKETS HARBOR
QUADRANGLES
LAKE
ONTARIO

Figure 6

DRAINAGE

Over one hundred years ago, Emmons (1842, pp. 369-371) noted the parallelism that is so characteristic of the drainage pattern in Jefferson County. The alert Dr. Emmons described in much detail the northeast-southwest trend of the streams, lakes, channels and grooves. His observations were so accurate and his descriptions so clear that the writer cannot but conclude that had the glacial theory been proposed before Emmons' survey his report would have left little to have been accomplished by the present investigations. It is indeed noteworthy that the physiographic aspect of this classic journal need only to have the most up-to-date knowledge of glacial activity applied to its descriptions to make it accurate in almost every detail. As was so vividly pointed out by Dr. Emmons, the most striking feature of the drainage is the parallelism of the stream courses in the area of this study.

The Black River

The largest stream in the area mapped is the Black River. The portion of the two quadrangles which this stream actually drains, however, is very small. Since the Trenton Escarpment of the Ontario Hills and the Tug Hill Plateau are so near the Black River channel, the drainage area of this stream is restricted, with the exception of Rutland Hollow, to the river valley (figures 5 and 6). The dip of the strata south of the river is to the southwest and, therefore, the normal runoff is away from the Black River.

The channel of the Black River, in the area studied, is cut into the Chaumont Limestone of the Black Water Group. The surface of the limestone is quite level and the river flows through a notch that is very shallow for the size of the stream it contains. In this area, the name Black River Valley is really a misnomer because a valley, in the fullest sense, does not exist. According to Fairchild (1910, p. 144), the course of the river west of the Great Bend is the result of glacial diversion and, therefore, this segment of the channel has been carved by postglacial down cutting. Comparison of the shallow channel of this section with the deep valley upstream from Carthage emphasizes the more recent age of the lower portions.

The Black River has long been noted for its waterpower, and the stream gradient, even in the Watertown area, is sufficient for industrial use. The nongraded profile is evidenced by falls and rapids along the entire course of the stream.

Drainage of the Eastern Ontario Hills

South of the Black River Valley, the Watertown and Sackets Harbor Quadrangles are drained by streams that flow west and southwest across the lake plain to Lake Ontario. These streams, except for those in the southern part of the Sackets Harbor Quadrangle, have courses which are relatively straight, but along which sharp angular changes in direction are common. In general, the stream pattern resembles trellised drainage (figure 6), but since this characteristic is in no way related to structure, it could not be so designated. The parallel pattern can be attributed mostly to the erosive work of the Pleistocene glaciers, with added effects of border drainage along the ice margin, the dip of the strata and headward erosion.

The direction of the ice movement (figure 7) attests to the fact that most of the streams that flow southwestward, either along part or all of their courses, follow channels that were carved by glacial ice. In most cases, only a small segment of any particular stream occupies a glacial channel, but such channels usually contain several streams that follow them for short distances. For example, the channel which begins in Rutland Hollow, in the northeast corner of the drainage map (figure 6), contains sections of Mill Creek, Stony Creek, South Stony Creek, the Adams Swamp and a small segment of Sandy Creek. This channel can be traced continuously in the field, and its course parallels the direction of ice movement (figure 7).

Certain channels seem to exhibit evidences that the drainage was at one time in the opposite direction. The only channel which definitely reveals this, however, is the one now occupied by Beaver Meadows Swamp, southwest of Watertown (figure 1). The sediments of this depression show a gradation from sand to silt to clay which offers conclusive proof of northeast drainage. This isolated case, however, would hardly be sufficient to establish a former northeastward drainage for the whole area.

Swampy, poorly drained areas are very common throughout the area mapped. Most sections of the lake plain which do not contain swamps have been greatly reduced, in some cases to bedrock, by the wave action of Lake Iroquois. The swamps emphasize the irregular surface left by the retreating ice. Some depressions that would normally be swampy, however, have been filled by lake sediments.

The Ontario Hills Section is drained chiefly by three large stream systems. Two of these, Mill and Stony Creeks, completely cross the lake plain, but they do not extend into Tug Hill. The third, Sandy Creek, which crosses the Ontario Hills in its lower reaches, flows entirely across the Watertown and Sackets Harbor Quadrangles.

In addition to these rather extensive drainage lines, several shorter streams, such as Muskalong, Bradford and Little Stony Creeks, drain the western margin of the plain along Lake Ontario (figure 6).

The headwaters of Mill Creek flow southwestward in a glacial trough, and it is difficult to account for its northwesterly course after it abandons the ice-carved channel. From the drainage map (figure 6) it might be included that Mill Creek originated as a subsequent stream, later extending across the plain by headward erosion. The surface map (figure 1) discounts this possibility. About one mile east of Sackets Harbor the waters of Mill Creek plunge over a limestone escarpment, and for two miles east of the escarpment the stream flows over the surface of the bedrock. The stream has cut no channel into the bedrock, and it is apparent that its course is rather recent. At any rate, this is definitely not the profile of a valley that had been lengthened by headward erosion.

The writer concludes that the southwestward course of the lower reaches of Mill Creek is the result of regional tilting. As stated above, it is apparent that the bedrock furrow now occupied by Beaver Meadows Swamp was once a northeastward drainage route. This drainage was, no doubt, halted as a result of postglacial uplift which reversed the gradient of the Beaver Meadows depression. Since the segment of the stream south of the present position of Mill Creek still had a northward gradient, the consequence of the uplift was the establishment of drainage along the present course of Mill Creek, thereby draining the northern and southern ends of the depression.

Many geologists have noted the Beaver Meadows channel and have wondered why the Black River did not follow this course from Watertown to Henderson. Had the regional dip, when the course of the Black River was established, been the same as at present, the river would probably have followed such a route. The present course of the river, however, was well entrenched before uplift reversed the gradient, and the river remains in its original channel.

It is quite possible that the area east of Smithville, now drained by Stony Creek, was formerly a part of the northeastward drainage system described above. Like Mill Creek, the headwaters of Stony Creek follow a glaciated valley east and west of Talcott Corners. Its tributary, South Stony Creek (figure 6), flows northward from Adams Swamp in the same ice-cut channel. Southwest of Smithville, Stony Creek follows a steep-sided glacial valley to Lake Ontario. The widest part of this channel is now filled with Henderson Pond. Between Smithville and Henderson Pond, the valley bottom is wide, is covered

with lake sediments and has a gradient so low that the stream meanders back and forth across the valley floor.

The Tug Hill Drainage

Sandy Creek is the largest single drainage line in the area studied. The major portion of the Tug Hill Plateau mapped during this survey is drained by this stream and its tributaries. It will be established later in this report that the melt waters of a later ice episode used the Sandy Creek drainage way. It is not believed, however, that the stream owes its origin and position to this ice episode. All of the stream's characteristics indicate that it was well established before late Wisconsin time. The stream's position is undoubtedly related to the stratigraphy inasmuch as its course follows closely the contact between the Trenton limestone and the Utica shale (figure 5). The valley of Sandy Creek, cutting entirely through the Utica section, is deep and gorgelike. The dendritic patterns of the tributary streams that enter Sandy Creek from the south emphasize that they have been degrading for a much longer time than those to the north. Since the southern streams have unquestionably drained into Sandy Creek since the time of their origin, it is obvious that the master stream was well established before the last ice advance in this region. The position of Sandy Creek, along the terminus of the ice of a last Wisconsin maximum, is therefore coincidental.

The North Branch of Sandy Creek and its tributaries drain the Tug Hill section north of Sandy Creek. The valley of North Branch was carved by the glacier, and its course parallels the movement of the ice across this region. The tributaries of this stream, however, have courses that are seemingly more related to the recessional history of the waning ice. Freeman, Jacobs and Baynton Creeks, tributaries of the North Branch of Sandy Creek, have courses that indicate they were probably formed along the margins of the ice at different stages of its retreat. The headwaters of these streams originate in swamps or marshes that occupy shallow depressions in the surface of the glacial mantle.

The southern tributaries of Sandy Creek were not disturbed by the last ice invasion. They have therefore had sufficient time to develop dendritic patterns. This characteristic is very conspicuous on the drainage map (figure 6). The tributaries to the south have branching, treelike patterns which have lengthened into all areas. For this reason the southwestern corner of the area studied is better drained than most others. This does not mean, however, that the southern section is everywhere well drained. Much of this area is swampy and marshy,

but these features are smaller and less frequent than in the remainder of the two quadrangles. The extreme southern part of the Tug Hill Plateau, along the southern boundary of the area mapped, is drained by a network of streams that comprise the South Sandy Creek System.

The most striking features of the streams in the area south of Sandy Creek, particularly South Sandy Creek and its tributaries, are their canyons or gulfs. These are deepest and best developed in the Frankfort Formation. Since the sandstone layers of this formation are thin, they did not retard downcutting, but the more resistant beds have prevented mass wasting from keeping pace with downcutting. Therefore, the canyon walls are almost vertical, and some of the so-called gulfs are over 300 feet deep. The most spectacular of these is Inman Gulf, through which Gulf Stream flows. This canyon is 200 to 300 feet in depth for several miles. South Sandy Creek, west of Allendale (figures 1 and 6), has cut a deep gorge which was named Lorraine Gulf by Emmons (1842, p. 408). Lorraine Gulf, longest of any in the area, extends eastward to Worth and exceeds 200 feet in depth in some places.

THE PLEISTOCENE EPOCH

Basically, the Pleistocene Epoch of the Quaternary Period (Richards, 1953, p. 351) is a four-unit interval in geologic history, represented by four episodes of glaciation. It is estimated that the first ice advance, the Nebraskan, began about one million years ago. The Nebraskan was followed by three succeeding glacial maxima which have been named the Kansan, Illinoian and Wisconsin stages. During each glacial stage, the ice formed far to the north, probably in the mountains of the northeastern section of North America (Flint, 1952, p. 143), and moved out in all directions. At one time or another during this epoch, the whole east central section of the United States as far south as the Ohio River was covered by one or more ice sheets. Each advance of the ice was a slow, spreading out movement and, after the ice had moved to its maximum, the retreat was also a generally slow withdrawal.

After each retreat of the ice, there followed a period of deglaciation during which time the climate returned almost to normal. These interglacial stages have been named the Aftonian, Yarmouth and Sangamon. Many geologists believe that the present period can well be considered an interglacial stage following the Wisconsin Stage and is, therefore, a unit in the Pleistocene. Although it is correct to say that the ice deployment and retreat progressed slowly in the ordinary concept of time, geologically speaking, the whole Pleistocene Epoch

was a very short interval, and the glaciation of North America was a matter of four ice advances and retreats in rapid succession.

Evidence shows that the area of New York State was covered, or partially covered, by at least three ice invasions. The manifestations of the last, or Wisconsin Stage, is by far the most widespread and the most studied. This, of course, is explainable since it was the most recent, and the drifts have not been effected by later ice movements. Indications are, however, that the ice also moved over the State in the two glacial stages that preceded the Wisconsin. Drift of Illinoian age has been recognized in the southwestern part of the State (MacClintock and Apfel, 1944, p. 1160 and Flint, 1947, p. 290). No drifts of pre-Illinoian age have been discovered in this area, but deposits which are believed to have been deposited during the second (Kansan) maximum extend beyond the Illinoian border in Pennsylvania (Flint, 1947, p. 291). It seems logical to assume that the ice which deposited these older materials in Pennsylvania must have moved across New York in order to reach the more southerly region. Evidences of this invasion could well be absent in New York State since two subsequent ice episodes have greatly changed the surface.

As previously stated, the most widespread glacial deposits in this State were left by the last (Wisconsin) ice activity. Because of its recent age, it offers the most complete record of events during a single glacial stage. Detailed study of the deposits made by the glacial advance reveal that the ice margin fluctuated between definite limits of advance and retreat. This has made it possible to divide the Wisconsin into units, representing four intervals of advance and retreat. These units have been designated substages, and each was followed by an interval of deglaciation called an interstadial. The substages are named the Iowan, Tazewell, Carey and Mankato or Valders.

The term Valders was originally used to designate the latest glacial drifts east of the Rocky Mountains. These deposits were first thought to be of earlier age than those called Mankato in the western Cordillera region. However, Antevs (1945) and others have correlated these as being the same age and have argued that they should all be termed Valdera. Many glacial geologists in the midwestern section of the United States have generally followed this suggestion, preferring to use Valders for the last substage of the Wisconsin (Thwaites, 1946, p. 86). The writer has heretofore used the term Valders instead of Mankato, but, since Mankato is more generally accepted in this area, it is used in this report.

The first substage of the Wisconsin, the Iowan, has been considered to be an advance of the ice into the north central section of the United

States from the so-called Keewatin Center. It has been assumed, therefore, that no ice invasion occurred in the eastern United States at that time. MacClintock and Apfel (1944, p. 1180), however, believe that the Olean moraine in the Salamanca area might have been deposited by this advance. During the Tazewell (second) substage, the Wisconsin probably had its most widespread effect, and manifestations of this episode are present in most sections where Wisconsin deposits are found. MacClintock and Apfel (1944, p. 1162) are certain that either the Binghamton or Olean moraines, or possibly both, are of Tazewell age. These writers conclude that the Olean moraine, and possibly the Binghamton, are of pre-Cary age, that the Tazewell is definitely represented, and that the Iowan is a possibility.

It is generally agreed that the Valley Heads moraine is of Cary age and possibly marks the terminal position of this ice. The Mankato ice advanced to the position of the Alden, Morrilla, Hamburg and Gowanda moraines in the Buffalo area (Leverett, 1913, p. 302), but the contact of the Mankato and Cary drifts has not been marked in the area east of the Rochester.

It is apparent from the above summary that the area of New York was subjected to severe ice erosion during the Pleistocene and was the site of widespread glacial deposition throughout this glacial epoch.

The Pleistocene in the Area of Study

During the Wisconsin Stage of glaciation, the Labradorian ice of the Laurentide Ice Sheet invaded the area surveyed in this study. As the ice deployed from the so-called Labradorian Center, it did not move en masse, but in tongues, called lobes. The tongue of ice which moved down the St. Lawrence Valley into the Ontario Basin has been designated the Ontario Lobe. Although this segment moved southward into the St. Lawrence Valley, the troughlike structure of the valley lowland altered its motion to a direction approximately paralleling the river (Owen, 1951, p. 18 and Chapman and Putnam, 1940, p. 426).

In addition to its general direction of movement through the valley, the spreading of the ice caused the development of secondary lobes. Their motions were influenced by both the westerly direction of the master lobe and the southerly direction of the expanding margins. These two components of motion gave the ice which moved into the Watertown and Sackets Harbor Quadrangles a south-southwest direction.

Such a body (lobe) of ice moved southwestward to the northern end of Tug Hill, and although the ice eventually moved up over the

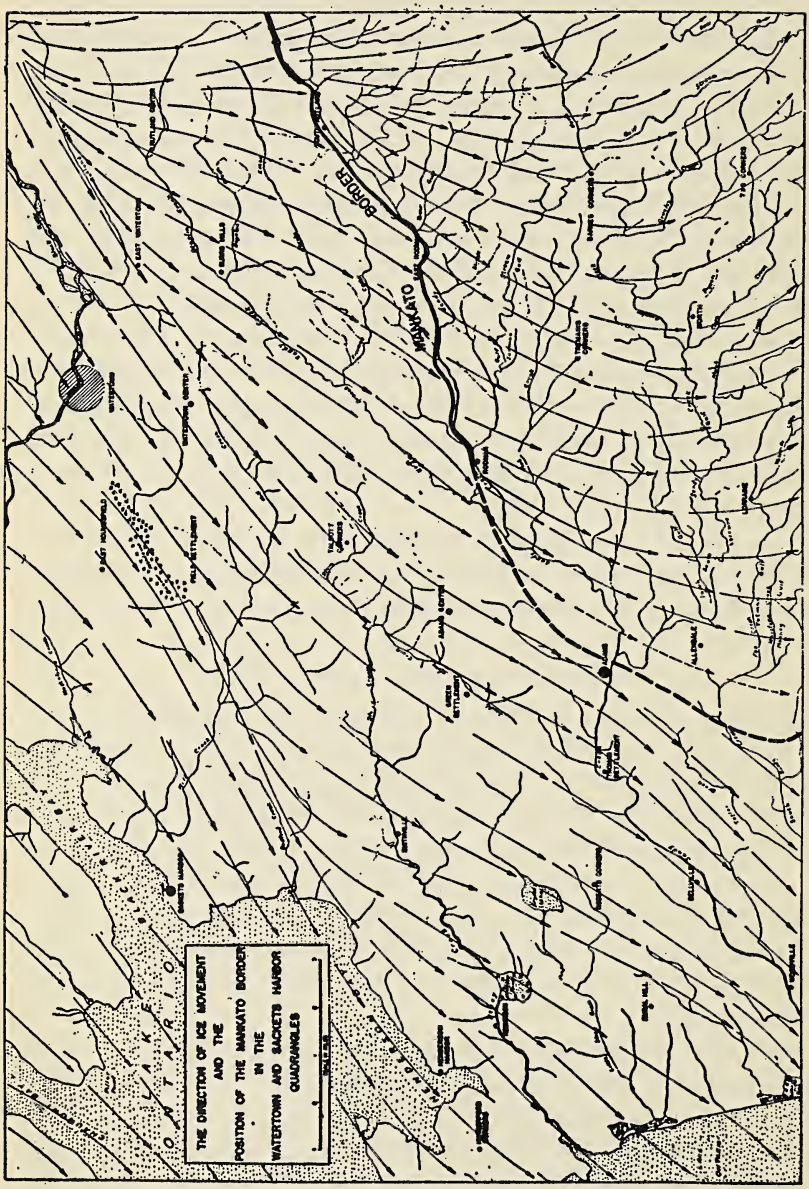
THE DIRECTION OF ICE MOVEMENT
AND THE
POSITION OF THE MANKATO BORDER
IN THE
WATERTOWN AND SACKETS HARBOR
QUADRANGLES
MILES
ONTARIO
BORDER
MANKATO

Figure 7

escarpment, the major portion of the ice divided and moved around either side of the cuesta.

The eastern segment of this divided ice mass moved up the Black River Valley, to the east of Tug Hill. It has been designated the Black River Lobe. The segment on the western side of Tug Hill moved south-southwest across the Eastern Ontario Hills. Although commonly called the Ontario Lobe, this tongue will be designated the Watertown Lobe in this report to distinguish it from the master lobe that moved through the St. Lawrence Valley and into the Ontario Lake Basin. That this (Watertown) lobe was distinct from the master lobe is evidenced by the direction of the drumlins south of the Sackets Harbor Quadrangle. There the drumlins formed by the Watertown Lobe (oriented north and south) are almost at right angles to those formed by the ice moving outward (east and west) from the Ontario Lake Basin (Fairchild, 1907b, plate V.).

AGE OF THE DRIFT

The age relationships of the glacial drifts in the New York area are probably the least studied of all the problems of the Pleistocene history. Leverett (1902 and 1915), in his studies of the till sheets in Ohio, Michigan and Indiana, traced several moraines of known sequence into the extreme western part of the State. The work of MacClintock and Apfel (1944) in the area of the Salamanca reentrant added greatly to the interpretation of the glacial history of the southwestern part of New York. Taylor (1924) made an attempt to trace a few moraines of known age from the vicinity of Rochester to the Watertown area, but certain discrepancies are apparent in this correlation and will be noted later. Holmes (1952) has done extensive till fabric studies in the Finger Lakes area in an effort to ascertain the age of the drift. These few studies, to the writer's knowledge, are the only investigations that have been concerned with the age relationships prior to the recent work of MacClintock (1953).

Two years ago, MacClintock started mapping the surface deposits in the St. Lawrence Valley for the New York State Science Service. His report of progress (MacClintock, 1953) on his first summer's work is now in press. The writer had occasion to visit Professor MacClintock in the Malone area during the summer of 1955 and to discuss some of the problems of correlation with him.

In his studies of the surface deposits in the St. Lawrence Valley, MacClintock has made investigations to determine the age of the drift. In these surveys, he has found a marked difference in the depth of leaching in two drifts. His conclusions show that a belt which is

leached to depths of five to seven feet in northern New York can be traced westward into Ohio. The younger drift is leached to depths of only one to two feet.

Using the procedures followed by MacClintock, investigations were made to determine whether or not more than one till sheet was represented in the Watertown and Sackets Harbor Quadrangles. The absence of any extensive outwash deposits on the Tug Hill Plateau had led to the conclusion that the drift in this section was all deposited during a single ice invasion. Using the policy of restricting leaching tests to gravel deposits, as MacClintock (1953) has done, it was immediately found that two different till sheets occur in the area of study. Whereas, the gravel of the kamic moraine immediately to the north of Sandy Creek was leached 18 inches or less, the gravel in similar kame structures in the southwestern corner of the Watertown Quadrangle was leached to a depth of eight feet.

Since the two kame areas mentioned above were the only gravel deposits available for comparison, it was necessary to experiment with other types of glacial materials to establish the contact of the two tills. Further comparisons proved conclusively that all types of younger drifts were leached less than corresponding kinds of older tills. It was possible to determine that a younger drift was leached to depths of 15 to 18 inches in clayey till, 2 to 4 feet in sandy till and 1 to 2 feet in gravel. The older tills, in contrast, were leached 5 to 7 feet in clay, 6 to 10 feet or more in sand, and 7 to 8 feet in gravel. By comparing the depths of leaching of similar types of glacial materials in areas of close proximity to one another, the border of the younger drift was established.

The results of these tests are recorded on the maps (figures 1 and 7). The last ice sheet moved up over the Tug Hill Escarpment and as far south as Sandy Creek Valley. Thus the kamic moraine and the sandy moraine to the east of it (immediately to the north of Sandy Creek) probably represents the terminal moraine of the last ice advance (figure 1). Taylor (1924, p. 653-654) correlated this moraine with the Albion in the Rochester-Buffalo area. The Albion, however, is a recessional moraine and is, therefore, believed to be later in age. It should be noted, however, that Sandy Creek acted as a border drainage along the margin of this later ice front. It is therefore possible that the ice, in its greatest extent, terminated in the valley of Sandy Creek, and thus the till of the terminal moraine was washed away by melt water. This seems improbable, however, inasmuch as no remnants of a moraine were found in the valley, and kame terraces along the

creek near East Rodman seem to indicate that ice invaded only this segment of the valley.

The position of Sandy Creek, along the margin of the ice, explains the absence of an outwash apron beyond the terminus of the last ice drift. Material washed out from the ice border was undoubtedly carried away by the waters of Sandy Creek.

THE GLACIATION OF TUG HILL

As has been previously stated, a massive ice sheet moved into the Watertown area from the direction of the St. Lawrence Valley. Upon encountering the promontory of the Tug Hill Plateau, the ice was temporarily halted and split into two lobes which were able to move around either side of the escarpment. Eventually the ice thickened until its surface rose above the elevation of the cuesta, whereupon the glacier was able to move on over the plateau. Evidence of its eventual movement over the summit is found in the glacial drift which covers its surface.

It has been assumed that the thickening of the ice occurred mostly in the lobes to the east and west, and that the ice which moved over the plateau came mostly from those directions. Such hypotheses have led to the conclusion that the Watertown and Black River lobes expanded to cover the top of the Tug Hill, and finally joined on the summit.

During this survey, investigations were made to determine whether or not the zone of contact of the two ice masses (Watertown and Black River lobes) extended as far west as the Watertown Quadrangle. Except for the directions of ice movement as manifested by the topography, chiefly drumlins, no definite distinguishing criteria could be established. The directions of the ice advance, however, lead to the conclusion that the Black River Lobe did not extend into the area of this study. Evidences also indicate that the Watertown and Black River lobes did not meet on the summit. It can be seen on the map showing the ice movement (figure 7) that the Watertown Lobe overrode only the western margin of the plateau. The same map also shows that the ice which piled up in Rutland Hollow rose over the obstruction and moved almost due south across the western edge of the Watertown Quadrangle. This leads to the conclusion that when the western part of the plateau is mapped it will reveal that the Black River and Watertown lobes were separated by a third lobe that moved southward from Rutland Hollow.

Since it was necessary for the glacier to thicken before moving over the plateau, the ice which extended over the summit was relatively thin and, as a consequence, the drift deposited on the plateau is also rela-

tively thin. In general, it can be stated that Tug Hill is covered by a thin veneer of glacial drift, and therefore the influence of the bedrock is everywhere a factor to be considered.

It has been established that the Sandy Creek channel was used as a border drainage along the terminus of a late glacier when it stood at the position of its maximum advance. In addition to separating drifts of different ages, this creek also marks the approximate boundary between the limestones of the Trenton Group and the Utica and Lorraine shales (figure 5). Except for a narrow outcrop of Utica shale between Rodman and South Rutland, all the glacial materials north of Sandy Creek are underlain by limestone, whereas those to the south of the creek are over shale (figure 5). The abrupt lithologic change produces corresponding differences in the drift. This being the case, the creek forms a natural boundary between two regions of distinctly different characteristics. Because of these differences, the two sections will be discussed separately in this report.

The Tug Hill Drift North of Sandy Creek

The glacial deposits north of Sandy Creek are of a younger age than those to the south and are resting upon various limestone members of the Trenton beds. The importance of the bedrock in this section cannot be overemphasized. This is true in all areas of this report, but on Tug Hill the bedrock influence is of even greater significance. The limestone layers of the Trenton are interbedded with shales of varying thicknesses. The most noticeable erosive effect of the ice moving over the strata was the planation of the layers along zones that were weakened by the shale partings. The result was a definite leveling of the plateau top, except for rises in the form of bedrock terraces. This action minimized the effects of glacial abrasion which produce such features as grooves, chattermarks and striations. Furthermore the abrasive features which were produced have been greatly reduced by solution weathering of the limestone.

In many areas of the Tug Hill upland, the pressure of the ice overburden caused the limestone strata to be buckled or warped. In many outcrops, the layers have an appearance similar to that produced by regional folding and metamorphosis. Such distorted beds are common to the west of the North Branch of Sandy Creek in the vicinity of Whitford Corners. In this area, the till is thin, and structures are exposed which were undoubtedly formed subglacially and near the ice terminus. The topography produced by these features resembles kames and eskers, but their structures are definitely the result of pressure.

Plate III

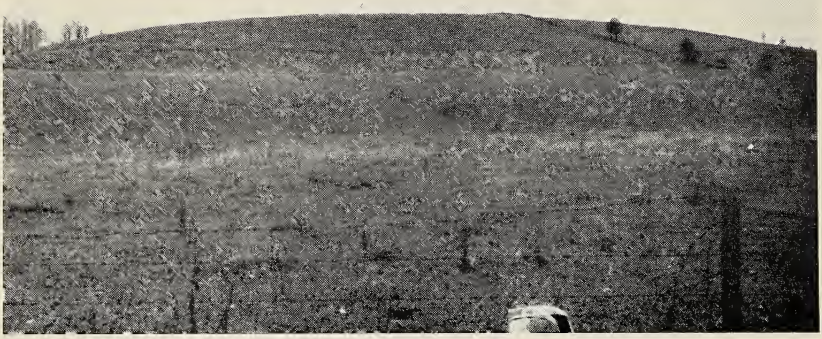

Figure 1. Streamlined drumlin atop the Tug Hill Plateau, two miles south of Talcott Corners. Northern (stoss) slope at left.

Figure 2. Bouldery clay till. Forty-foot exposure in roadcut through drumlin, one mile northwest of Rodman.

The bedrock influence is also apparent in the composition of the drift. Since the bedrock is limestone, the surface materials contain a high percentage of calcium carbonate. Inasmuch as the drift was deposited during the last glacial advance, leaching has removed the carbonate to depths of only one to three feet. The high lime content is most apparent in the soils of this section, and it is here that the most productive farmlands of the immediate area are found. Dairying is by far the most important agricultural practice.

In addition to the high lime content, the till contains a very large number of limestone boulders. Although crystalline boulders are found in numbers which would normally be expected in this area, the concentration of limestone blocks is much above the average. The glacial plucking of the limestone layers along lines of weakness resulted in the production of angular, blocky fragments. Some of these are large, but because of the spacing of the shale partings, most of them are less than three feet across. The effects of glacial grindings were small because of the short distance of transport; hence the limestone boulders are still quite angular in their overall shape. The corners and edges are rounded in varying degrees, and striations are common on blocks found in the unweathered till.

The till of the plateau north of Sandy Creek is clayey and bouldery. The percentage of sand is usually higher than the physical characteristics would indicate, and the relative amount of sand increases southward. Immediately north of Sandy Creek and east of the kamic moraine, the till along the later border is composed predominantly of bouldery sand. This indicates great water activity along the ice margin at the time the material was deposited. The drift in this area is very similar to the kamic moraine in composition, but the concentration of boulders is greater, and the sediments are unsorted in the till.

The kamic moraines are composed of clean, well-sorted gravel, and ice contact structures are abundant. The kames of the terminal moraine, immediately north of Sandy Creek, are not very high, but they have steep slopes, and the surface expression is conspicuously domelike. The gravel of the terminal area laps upon the slopes of the drumlins that are scattered throughout the moraine.

The drumlins on Tug Hill were mapped to assist in determining the direction of ice movement. These are composed of clayey till (plate III, figure 2), and, as in the case of the moraines, the sand content increases toward Sandy Creek. The drumlins are definitely of the type described by Fairchild (1907a, p. 413) as having been formed by plastering action. The streamlined shape (plate III, figure 1), common to drumlins, is most conspicuous in this region, and the

steeper, or stoss, slope is easily distinguished. The drumlins seem to be concentrated in certain areas, but the significance of this could not be determined.

The North Branch of Sandy Creek parallels the direction of ice movement, and its valley was undoubtedly carved by the glacier. The valley walls are steep and are covered in certain areas by kame terraces. The stream gradient is very low, and the valley is much wider than the size of the stream would require. Taylor (1924, p. 654) infers that this stream was established as a border drainage along the margin of the receding Mankato ice. This assumption was developed from his belief that the moraines north and west of the stream, and particularly the kamic moraine in the Dry Hill area, were recessional moraines marking a retreat of the ice. This conclusion is contrary to observed facts, however, inasmuch as the ice movement was parallel to the creek (figure 7) and recessional moraines would extend at right angles to this direction. The kamic moraine in the Dry Hill area parallels the North Branch of Sandy Creek and has characteristics in some places very much like an esker. It is apparent, therefore, that the long direction of this feature also parallels the direction of ice movement.

It is believed that the angular courses of some of the tributaries of the North Branch of Sandy Creek do indicate border drainage inasmuch as they extend more or less at right angles to the direction of the ice movement. These streams include Freeman, Jacobs and Baynton Creeks. Had this study been concerned with the recessional halts of the glacier, the positions of these streams would have been considered pertinent in such determinations. However, because of the thinness of the drift and the absence of any definite morainal ridges, it was concluded that the ice withdrawal resulted more from stagnation than from the melting back of the glacier while it was still active.

One of the most interesting features in the northern section of Tug Hill is Rutland Hollow, three miles east of Watertown. It is a typical glaciated valley in the textbook sense. It has a wide, swampy bottom and kame terraces cover the steep valley walls. The ice moved through the valley from the northeast. The retreat of the ice is evidenced by esker-like kamic moraine on the valley floor paralleling the valley and an area of massive recessional moraine which blocks the valley to the northeast.

The ice which encountered the Tug Hill escarpment approached from the northeast and moved down the valley that is now Rutland Hollow. It is impossible to determine the drainage pattern before the advance of the last glacier; however, it is suspected that a valley

existed which facilitated the movement of the ice into the area that is now Rutland Hollow. Thus, the ice moved down the hollow and the valley was carved parallel to the direction from which the ice approached (figure 7). It was in this hollow that the ice piled up in order to move upon the plateau.

The kame terraces which cover the valley walls along Rutland Hollow are very thin, and bedrock is exposed on either side. However, the terraces merge to form a large kame terrace which closes the valley at its southwestern end. This terrace is worthy of special comment. The terrace gravel extends completely across the valley and for a distance of about two miles beyond its southern end. The gravel composing the terraces is well sorted, clean and used extensively for commercial purposes. The structures which can be seen in various gravel pits include all of those generally associated with ice contact features. There is a great range in the textures of the gravel in the various zones of its vertical section. Minute structures such as normal and reverse faults, grabens, horsts, rolled bedding, foreset bedding, frost heave and ice shove are most common, and certain sections have till imbedded in them. The writer considers these to be excellent examples of ice contact structures, and photographs taken in some of the pits are included in plates IV and V.

Taylor (1924, p. 657) and Fairchild (1912, plate IV) believed the Glenfield Stage of the glacial lake in the Black River Valley drained for a short time through Rutland Hollow and Mill Creek Valley. It is also inferred by Fairchild that this lake once overflowed through the Sandy Creek Valley. This survey did not include the upper reaches of Sandy Creek, and therefore no data were obtained that have bearing on this channel. However, since Rutland Hollow is blocked by a moraine at the northeast and a kame terrace at the southwest, it seems that evidences of such drainage would be conspicuous had the hollow been used as a lake exit. No such manifestations were found during this survey, and it seems unlikely that the lake waters overflowed along this course. The abrupt ending of the high level shore features of Lake Iroquois at the southwest end of Rutland Hollow and along the northern slope of Tug Hill (figure 1) leads the writer to conclude that ice remained in Rutland Hollow long after the glacier receded from the Watertown area. Since the ice approached from the northeast, it would recede in this direction, and it is doubtful that Rutland Hollow was free of ice until about the time the Lake Iroquois waters merged with the lake waters of the Black River Valley. If either of these assumptions is true, it would have been impossible for a lake in the Black River Valley to have used the Rutland Hollow

channel, notwithstanding the fact that no evidence of such was found during this investigation.

Tug Hill Drift South of Sandy Creek

The change in the character and appearance of the glacial drift as one goes from the territory north of Sandy Creek (described above) to the area south of it is so abrupt that it is difficult to describe. It does not suffice to note that the surface deposits on opposite sides of the stream are of different ages. There is also a distinctive change in the materials comprising the drift that is not only different in the two areas (north and south of the creek) but which also effects a series of changes within the southern section. The differences result from a combination of factors, the most noticeable of which include the age relationships of the drift, the character of the bedrock and erosion.

As has already been explained, all the drift of this section is considerably older than that to the north. For this reason, leaching has progressed further, and the removal of the soluble constituents has been more complete. This fact is most conspicuous in the soil and the resulting utilization of the land. Most of the land south of Sandy Creek has been used for farming at one time or another, but for the most part the farm homes have been abandoned. The whole section is now devoted chiefly to State forests, game preserves and hunting clubs. A few progressive farms are still operated along the main highways, and these are seemingly producing well. However, the soil requires treatments which are expensive, and the results are slowly realized.

In addition to leaching, processes of mechanical erosion have been operative for a longer period. The streams have cut deeply into the surface deposits, but the effect of time on the streams is most noticeable in their patterns. The streams north of Sandy Creek still reflect the influence of glacial erosion, but in the southern area they have had time to develop a more mature pattern. Although a pattern resembling trellis drainage is still the rule in the north, a dendritic pattern has evolved south of the creek. It should be stated, however, that poor drainage is still prevalent in this area and swampy or marshy depressions are very common.

The bedrock explains the confusing appearance of the drift south of the creek and the differences which are evident between the creek and the southeast corner of the quadrangle. The Utica shale underlies the drift immediately south of Sandy Creek. Since this unit was soft it was easily eroded and picked up by the moving ice, but much of it was soon redeposited in the area of the outcrop. The high content of

PLATE IV

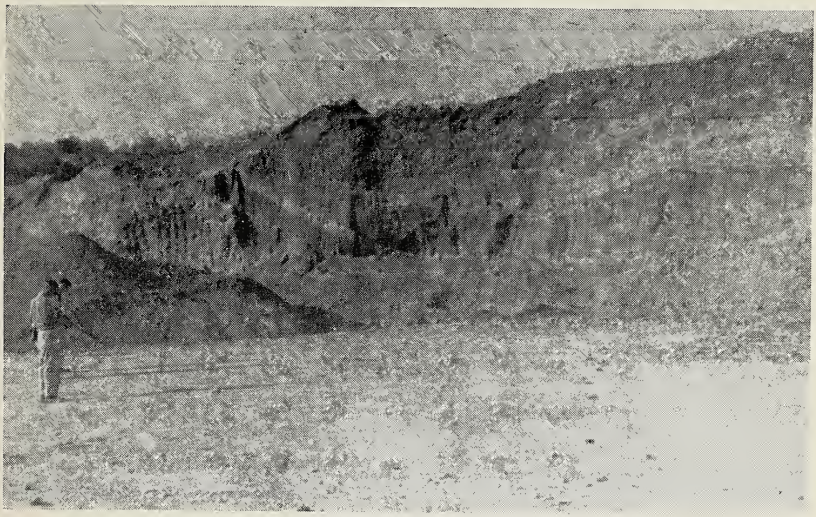

Figure 1. Ice contact structures in kame terrace gravel, two miles southeast of Watertown

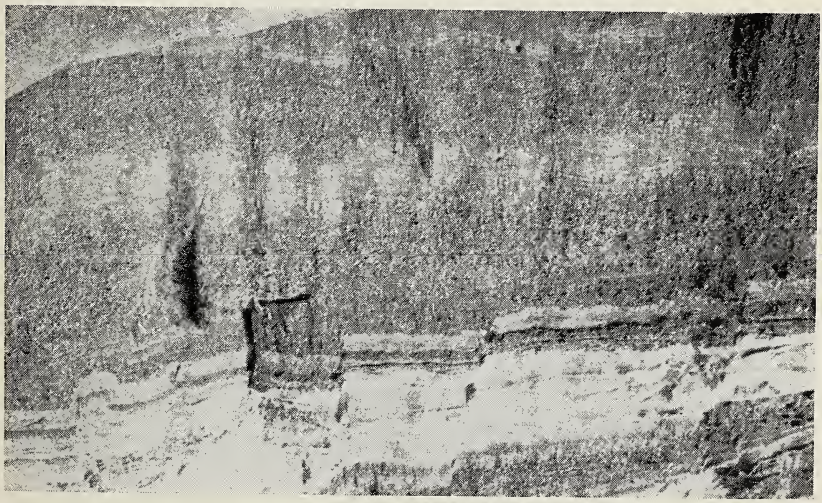

Figure 2. Faulting in kame terrace gravel indicating ice contact conditions, two miles southeast of Watertown

PLATE V

Figure 1. Bouldery clay till buried in kame terrace gravel, two miles southeast of Watertown

Figure 2. Horst in kame terrace gravel indicates ice contact deposition, two miles southeast of Watertown.

shale in the deposit makes the latter appear more like weathered bedrock than till. The Utica is thinly bedded, and the fragments included in the till are consequently small and thin. Some zones of the Utica contain enough sand to make them quite hard, and thin fragments from these zones have slatey characteristics. Such properties led Emmons (1842, p. 397) to map this formation as slate, and the farmers in the vicinity still refer to the "slate rock" soil. The Utica influence is greatest within one to two miles of the creek.

Beyond the Utica shale, the Frankfort shale forms the bedrock (figure 5), and this formation differs from the Utica in its content of thinly bedded, gray sandstone layers. These sandstone bands, usually less than six inches in thickness, increase in size and frequency toward the top of the formation. Therefore, the thin slabs of sandstone which distinguish the till of Frankfort parent material become more abundant in the direction of Barnes Corners. The till here resembles rock mantle formed by the weathering of thin-bedded sandstone because the sandstone slabs show no evidence of glacial grinding and are accordingly very angular.

South and east of Barnes Corners the influence of the Pulaski Formation predominates in the drift. The results are even more flaggy fragments occurring in the till and a change of color due to iron. The sandstone layers in the Pulaski have a high iron content and weather to a hematite brown. This color is the most conspicuous property of the drift in the southeastern corner of the Watertown Quadrangle.

The kamic moraine in the extreme southeastern part of the area of study (figure 1) is composed of gravel that is predominantly of Pulaski parent material. The gravel, therefore, consists chiefly of gray to brown shale and brown weathered sandstone. The kames show excellent ice contact structures and are well sorted, but the gravel is of little economic value except for road construction. The kames are exceptionally well developed with steep slopes and domelike tops. The writer is led to believe that this kame area will have an important bearing on the glacial history of the Tug Hill Plateau when the mapping is completed. However, only the northwestern edge of this kamic moraine was mapped during this survey and its significance could not be ascertained.

THE GLACIATION OF THE LAKE PLAIN

Between Lake Ontario and the Tug Hill Plateau, the Erie-Ontario Lake Plain was severely eroded by the glacier as the ice moved across it. Since the relief of this section was less than that of Tug Hill, it was not necessary for the ice to pile up in order to move over it. Therefore,

the lake plain was covered by a much greater thickness of ice, and the effects of abrasion were correspondingly increased.

Glaciation of the Black River Valley

The results of glaciation in the Black River Valley are quite simple. The Chaumont limestone, forming the bedrock of the valley, is very resistant; hence it withstood the brunt of glacial abrasion with little or no change. The Trenton limestone was removed from over the Chaumont but, except in a few cases, the ice did not scour the Chaumont to any great depth, leaving the surface quite flat and expressionless.

In areas where the surface of Chaumont limestone has been exposed by recent excavations, striations and shallow grooves are found in great numbers. Such an exposure is found in the Sackets Harbor Quadrangle where lake clay had been removed from over the Chaumont for use in constructing runways of the nearby Watertown Airport. This location is along the south side of the Black River, about one mile east of Dexter. In the small area exposed, two sets of striations were found, showing the ice movement to have been S. 35° W. and S. 5° W. This was the only exposure in the two quadrangles where striations could be accurately measured. The only deep, steep-sided channel carved by the ice in this section is that now occupied by the Black River Bay. This seems to be a small fiord-type inlet. Chaumont Bay is of similar origin.

Glaciation of the Eastern Ontario Hills

The surface of the Ontario Hills is irregular and bedrock terraces are very common. There are many localities in this subdivision where the ice thickened to move over an obstruction or changed direction to move around it. The most important single reason for the irregular surface of this hilly section, especially its northern part, is the differential resistance of the formations comprising the Trenton Group. Whereas some layers are most resistant, other layers are soft and these were easily removed by the advancing ice. The variable resistance is caused by the presence or absence of shale in the limestone. In a few layers, the shale is evenly distributed throughout, but more commonly it is concentrated in narrow bands. Because of weakened zones caused by shale partings, the limestones above the partings were planed off by the ice. For this reason, most of the slopes are steep and rise in steplike terraces.

In many areas, small, isolated, buttelike rock remnants are common. These were formed by the concentration of ice abrasion in channels that were carved around them. Many of the bedrock slopes have kame terraces on their sides, and it is believed that most of them

would have gravel deposits along their flanks had the gravel not been later removed by wave action during the existence of Lake Iroquois. The summits of these rock remnants are flat, but have a slight dip to the southwest, with that of the bedrock. Most of these features show evidence of having been covered by till before they were washed by waves during the Iroquois episode.

There are many glacially carved channels in this section of the area. Numerous parallel ones were noted by Emmons (1842, pp. 368-369) in his original survey of the Second District. The easternmost of these channels follows the base of the Tug Hill Escarpment east of Watertown and Watertown Center. This channel, now occupied by the headwaters of Hill Creek, separates the outlier on which Watertown Center is built from Tug Hill proper. A driller reported to the writer that a water well along Mill Creek, one mile south of Watertown Center, was drilled to a depth of 104 feet and was still in gravel when the drilling was stopped. This indicates a very deep channel filled with lake sediments. South of the point where Mill Creek turns westward, this channel continues southward. It is occupied by segments of several streams including the upper reaches of Stony Creek west of Talcott Corners, South Stony Creek in the vicinity of Green Settlement, Sandy Creek at Thomas Settlement and a tributary of Sandy Creek east of Bellville (figure 6). Only short segments of each of those streams follow the channel. Most of the streams, it is believed, have extended their courses into the glacial channel chiefly by headward erosion.

Another interesting channel of glacial origin begins at the western edge of the city of Watertown. This channel, which extends for several miles to the southwest of Watertown, now contains the Beaver Meadows Swamp. Beyond the swamp the channel is occupied by tributaries of Mill Creek and still farther south of Bedford Creek (figure 8). This is the channel to which Emmons (1842, p. 369) was referring when he wrote that he saw no reason why the Black River would not flow from Watertown to Henderson if the till which blocks it were removed. Actually, the river might flow either southward to Stony Creek, or southwestward to Bedford Creek if the obstruction were not present.

It seems evident, however, that a north-flowing stream at one time followed the Beaver Meadows depression to the Black River at Watertown. The manifestations of this stream are preserved in the sediments that now fill the channel. The southern and southwestern limbs of this depression are now filled with clean stream sand which grades into silt where it is crossed by Mill Creek. In the section now occupied

by the Beaver Meadows Swamp, light-colored clay underlies about three feet of muck and peat. The graduation from sand to silt to clay is indicative of currents flowing in the direction of Watertown (figure 1).

Henderson Pond and Crystal Lake also occupy bedrock depressions which were formed by glacial erosion. These are much shorter than the channels described above, but their origin is unquestionably the same.

It should be noted that the direction of the ice movement became more westerly in the northwestern corner of the Sackets Harbor Quadrangle. It is apparent that the southwest trend of the St. Lawrence Valley is responsible for this direction of movement. Since the path of the master Ontario Lobe passed close to the northwestern corner of the area of study, its influence on the ice movement in that section was greater than in the vicinities of Rutland Hollow and Watertown. The present course of the St. Lawrence River between Ogdensburg and Clayton (figure 2) is almost in a direct line with Chaumont Bay. It is obvious, therefore, that the ice in this section had a direction closely paralleling the path of the master lobes into the Ontario Basin. It is quite possible that the path of the Ontario Lobe into the basin extended as far south as the Black River Bay and that the present trend of Chaumont, Black River and Henderson Bays parallel the direction of the Ontario Lobe in this area.

The southward change in the direction of the ice movement south of Bedford Creek in the vicinity of Smithville (figure 7) is due to the influence of a steep escarpment of Trenton limestone. In this area, the ice thickened to move over the escarpment as did the ice in the Rutland Hollow, except on a much smaller scale. Stony Creek east of Smithville follows the base of a north-facing escarpment for about 4½ miles. The ice seems to have approached this obstruction, however, with a thickness great enough and at a proper angle to move over the cuesta without much change in direction.

It is difficult to reconstruct the surface conditions relating to structure and material as they were before the Iroquois-Frontenac episodes. Not only is much of the area covered by lake sediments, but wave action during the existence of the lake greatly diminished or completely removed the glacial drift in large areas throughout the section. It should be emphasized that the Iroquois waters expanded in front of the retreating glacier, and deposits made by the waning ice were undoubtedly laid down under the lake waters. Since the deposition took place in a lacustrine environment, and waves were active during deposition and for some time thereafter, it is surprising that any

recognizable glacial materials remain. It will be established in a later chapter of this report, however, that wave action of the lake stages was less intense in certain areas than in others and that glacial materials were concentrated in the areas where wave erosion was least active. Also, in some areas where wave erosion was quite severe, glacial deposits were shielded from the waves by bedrock promontories that were higher than the area they protected.

North of Stony Creek, between Smithville and Watertown, several rather large morainic areas were mapped during this survey. Consisting of patches of drumlin and morainic tills, they lie mostly between the 400- and 500-foot contours, an interval in which wave erosion was least effective. The moraines of this section are composed of a heavy clay till, and boulders are everywhere scattered over the surface. The till is covered by a veneer of lake sediments, but the lacustrine deposit is too thin to mask completely the till characteristics.

The orientation of the morainic remnants is parallel to the direction of the ice movement. This often causes an erroneous interpretation that these are lateral moraines. The orientation, however, as well as their preservation, is explained by their position on bedrock remnants which were carved out by the moving glacier. Since the rock remnants were isolated by the ice moving around them, their elongation parallels that of the ice movement. Therefore, the moraines which are perched upon them are deceivingly trending laterally. It is impossible to ascertain the original orientation of the morainic topography, although it seems likely that the deposition was along the margin of the retreating ice. If this is the true interpretation, the fabric of the till should be at right angles to that now reflected by the surface topography.

Another morainic remnant curves around the northern end of the bedrock escarpment south of Stony Creek in the vicinity of Smithville. This till area also lies between the 400- and 500-foot contours. It is free of lake silt except in its southwestern segment, which swings around the escarpment south of Smithville. The preservation of this morainic accumulation is due both to its elevation and to the fact it was protected from wave action by the escarpment. This is the best preserved and least eroded of all the morainic remnants of the lake plain. Its characteristics, therefore, probably best exemplify the glacial materials which originally covered the lake plain section.

The till composing the moraine has a very high content of clay, with sand and gravel predominating to the southwest of Green Settlement. Boulders, which include local limestone blocks and a high percentage of crystallines, both igneous and metamorphic, are strewn over the surface in great numbers. The lime content is high, as are other

mineral constituents, and the soil is very productive where slopes are not too steep to prohibit cultivation. The high clay content, however, makes cultivation almost impossible during dry seasons. From a purely agricultural point of view, the addition of lake sediments to the soil on the lake plain has improved its use for cultivated crops.

Many areas in the Ontario Hills were mapped as ground moraine or as lake sediments covering ground moraine. It should be emphasized that these designations were used to describe till areas in which the topography was level to undulating. In areas not affected by wave action the ground moraine legend connotes subglacial deposition. On the lake plain, however, it is impossible to differentiate between areas leveled by wave action and those left essentially level by subglacial deposition. It is probably that many of these areas owe their level surface, at least in part, to the erosive action of the lake episode.

The largest area of outwash mapped during this survey extends westward from the vicinities of Roberts Corners and Bellville almost to Lake Ontario. The western margin of this outwash plain has been removed by low level (probably Gilbert Gulf) wave action, and its southern extension is covered by thick deposits of lake sediments. The entire outwash plain is covered by lake sediments, but the northern portion could be mapped as lake sediments covering outwash because the lacustrine deposits are not of sufficient thickness to conceal the outwash completely. Since the lake silts covering the outwash thicken to the southward, the southern limits of the outwash were arbitrarily mapped along a line where the outwash influence was no longer apparent on the surface. At best, this boundary could only be approximated.

The gravel of this outwash is well sorted, is composed of a wide range of sizes and has a high lime content. It was impossible to determine the thickness of the gravel in most areas. It was found to be only 3 to 5 feet thick, however, along New York Route 3 (1½ miles west of Rural Hill) to the west, and over 20 feet in the vicinity of Roberts Corners. A gravel pit located one-half mile southeast of Roberts Corners is the only opening which shows the stratification and composition of the outwash.

Because of the recent activities of the lake episode (both erosional and depositional), it is difficult to make accurate leaching tests on the lake plain. Tests were made at the Roberts Corners pit, however, where the gravel is leached to a depth of only two feet. It is assumed, therefore, that this deposit was made during the retreat of the last ice invasion.

Numerous small kamic moraines were mapped in the area of, and adjacent to, the outwash. The kames definitely show ice contact

Plate VI

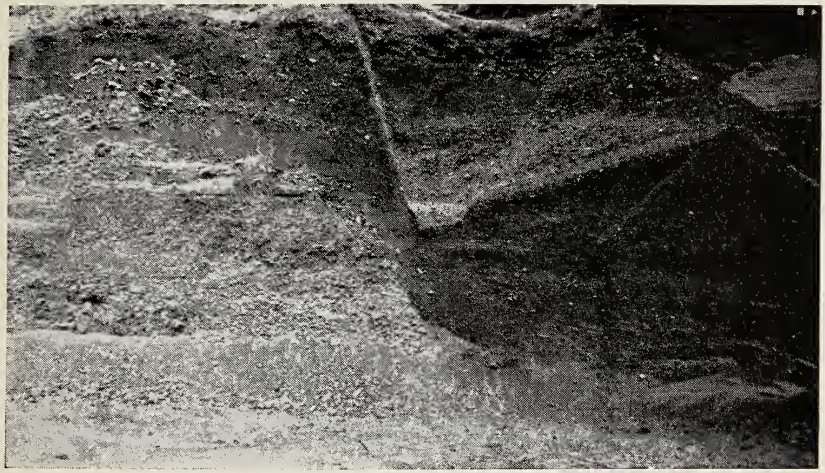

Figure 1. Normal fault in kamic moraine. Total height of exposure is 20 feet. Rural Hill.

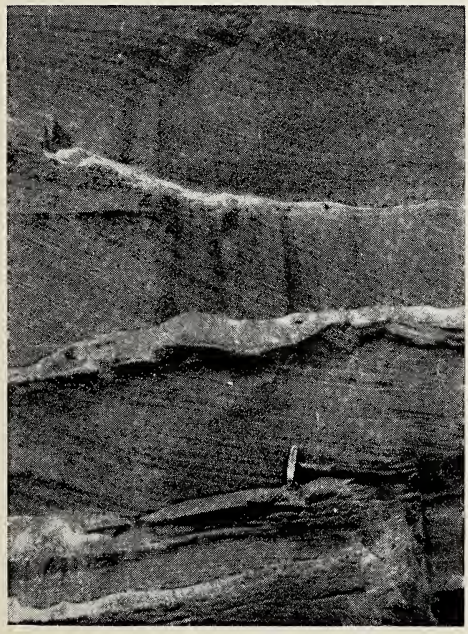

Figure 2. Foreset bedding in kamic moraine, one mile west of Rural Hill

structure (plate VI, figures 1 and 2). Those south of Rural Hill, however, are covered with thick lake sediments. The kamic moraine at Rural Hill is a very productive source of gravel, and at least six gravel pits have been operated in this small area, three of which are still in operation.

LAKE IROQUOIS

The glacial lake history of the Great Lakes basins west of Lake Ontario is recorded in lake strand lines which date from early in the Cary Substages of the Wisconsin. As soon as the Cary ice receded enough to allow water to collect, lake waters expanded in front of the retreating ice. Lake Maumee was established in the western part of the Erie Basin and Lake Chicago in the southern end of the Michigan Basin. From these beginnings, a continuous lake history can be traced from the shore phenomena in the Michigan, Huron and Erie basins. This record has been preserved because the Mankato ice did not completely fill these basins, and manifestations made by glacial lakes during the Cary were not destroyed.

In the Ontario Basin, however, it is believed that the Mankato ice completely covered the depression. It is probably that lake waters were impounded in front of the retreating Cary glacier, and lakes were no doubt formed in front of the advancing ice at the beginning of the Mankato Substage. But, because the Mankato ice scoured the entire basin, all evidences of prior lakes were obliterated. For this reason, only evidences of those lakes associated with the retreat of the Mankato ice still remain.

At its greatest extent, the Mankato ice covered the entire Ontario Basin and lapped upon the Appalachian Plateau Escarpment at least as far west as Syracuse. During this period, when the ice border reached to the plateau front, the waters of the Erie and Huron basins were trapped to the west and rose to a level of approximately 665 feet to overflow eastward through the Mohawk Valley. The actual escapes of these waters, around the ice margin, are recorded in the vicinity of Syracuse in the form of channels along the northern slopes of the Appalachian Escarpment. This stage in the Pleistocene history of the Great Lakes has been designated Lake Wayne (Taylor, 1915, p. 386).

A slight readvance of the ice, in the southern part of the Ontario Basin, blocked the outlet to the Mohawk Valley, causing the waters of the Erie, Huron and Saginaw basins to rise to a higher level, called Lake Warren. This lake, which had an average level of 680 feet, overflowed at Maple Rapids, Michigan, the spillwaters flowing westward to the Michigan Basin.

Later, as the Ontario ice lobe began its retreat, the lower outlet to the Mohawk was again opened. The drainage was therefore shifted back to the east, and Lake Elkton was established at a lower level (620 feet). This lake stage has also been called Lake Lundy and Lake Dana (Taylor, 1951, p. 399).

During the three lake stages described above (Wayne, Warren and Elkton) the Ontario Basin was blocked by ice except for a narrow strip along the southern margin in the area of the Finger Lakes. After the Elkton stage, however, a general ice retreat began in the region of the Great Lakes. As a result, the lake waters of the Superior, Michigan and Huron basins merged at a level of 607 feet to form one large lake, named Lake Algonquin.

The lowering of the waters in the western lake basins to the Algonquin level separated Lake Erie from the Algonquin waters, and the Ontario basin was isolated for the first time. Also at this time, the first independent lake in the Ontario Basin was formed, being limited to the Finger Lakes region and a small area to the north (Taylor, 1915, p. 325). This lake, which drained via the Syracuse outlet, is recorded in the geologic literature as Lake Dawson.

Lake Dawson was short lived because the Ontario Lobe soon retreated sufficiently to open an outlet at Rome. This established Lake Iroquois. Thus, as is recorded by Fairchild (1918, p. 62), "The lake (Iroquois) originated at the margin of the waning Ontario lobe . . . when the ice uncovered the southern part of the Ontario Basin." At first, Iroquois was a very long, narrow lake, occupying a narrow strip extending the whole east-west distance of the Ontario depression between the retreating glacier and the plateau. As the ice continued to diminish, however, the lake expanded over the deglaciated area. When the ice stood in the latitude of Watertown, the lake had increased in size sufficiently to cover the basin from Rome to Buffalo and extending as far south as the Appalachian Plateau at Syracuse.

After the glacier retreated beyond Watertown, the Iroquois waters extended around the northern end of the Tug Hill Plateau and merged with a lake that occupied the Black River Valley. Still later, Iroquois lake waters extended into the St. Lawrence River Valley along the northern slopes of the Adirondacks. When the ice receded to the north of the Adirondacks, it uncovered a col at Covey Hill that was lower than the outlet at Rome. As a result, the Iroquois level was lowered to the elevation of the Covey Pass, and the Rome outlet was abandoned. According to Taylor (1915, p. 325), the ice of the Ontario Lobe stood on the Frontenac Axis at the time of the shift from Rome

Plate VII

Figure 1. Washed-off till, two miles southeast of Adams. Boulders concentrated due to wave action.

Figure 2. Frost heave on washed-off till. Frost action indicates poor drainage, one mile north of Lakeview Pond.

to Covey Hill, and the lake that used the Covey outlet has been called Lake Frontenac.

Finally, when the ice was completely removed from the St. Lawrence Valley the lake waters were drained. Because the valley was then below the level of the sea, marine waters invaded the St. Lawrence Lowland. This marine phase was named Gilbert Gulf by Fairchild (1909) on the assumption that the waters were marine in both the St. Lawrence Valley and the Ontario Basin. Coleman (1936b, p. 73) has since proved, however, that ocean waters did not extend as far as Lake Ontario.

In the area of this report, the Lake Iroquois shore features to the south of Adams Center are quite different from those to the north. For that reason these two sections of shoreline are discussed separately.

The Lake Iroquois Shoreline between Watertown and Adams Center

The Iroquois shore between Watertown and Adams Center follows along the Trenton Escarpment of the Tug Hill Plateau at elevations between 710 and 745 feet. Because of the differential hardnesses of the Trenton strata, the slope rises in bedrock terraces which, at first, seem to be lake terraces. However, there are no lake terraces in this section of the shoreline, and the several lake levels must be established mostly from constructional features.

Since this investigation was especially interested in the uplift of the Iroquois shore, particular emphasis was given to establishing the highest water level. It was found, in this survey, that the highest level of Lake Iroquois is marked by a narrow band at the top of the lake sequence which was mapped as "washed-off till" (figure 1). This feature is erosional and of similar character to that commonly called a boulder pavement (Spencer, 1890). The most conspicuous characteristics of this band are the concentration of large boulders and poor drainage (plate VII, figures 1 and 2). The boulder concentration resulted from the action of waves lapping upon the shore removing the finer sediments and leaving the larger boulders in a strip. This marks the shore position at the time of highest wave action. In this survey, the elevation of the top of the washed-off till was taken as the high water mark. Although such features were described by Spencer as early as 1890, the writer has found no instances where such high-level features have been considered in similar investigations of the Iroquois shore. Between Watertown and Adams Center, the washed-off till is in a very narrow band, but it is very conspicuous and easily recognized.

Because the features were clearly defined, it was possible to make accurate measurements of the level of the water in its greatest extent.

Immediately below the washed-off till is a much wider deposit that is composed of beach gravel and contains a series of beach ridges. Except in the area of the kame terraces, at the mouth of Rutland Hollow, the beach gravel consists entirely of limestone, presumably having been removed from the Trenton layers along the shore. The beach gravels and ridges in the area of the kame terraces are composed of glacial materials similar in composition to the kame moraine above the shoreline and the kame terraces below.

The beach gravel, as well as the ridges, was formed on the lake shore, chiefly above the water level. It seems that the base of a beach ridge on the seaward side marks the shoreline at the time the ridge was made. The writer believes that the ridges have been given too much emphasis in the interpretations of former writers. Although numerous beach ridges were formed along the shore, the findings of this survey lead to the conclusion that the distribution of the ridges is more closely related to the slope and character of the shoreline than to the water level. It is actually possible to trace a ridge from one area to another and find that the two extremes are at different elevations. The most significant conclusion that can be drawn from the ridges, it seems to the writer, is that they record a gradual withdrawal of the lake waters from the high area marked by the washed-off till.

A second stable shore is marked by washed-off till 80 to 90 feet below the top of the highest level. Except for elevation, it is similar in all respects to the uppermost level. It is concluded that this band probably marks the level of the lake after the drainage shifted to the Covey Hill outlet and should therefore be called the Lake Frontenac shore.

Below the lower washed-off till, the lake sediments consist of shore gravel which grades outward into sand and finally into silt. Sandy sediments lap upon the Tug Hill Escarpment and fill the low area along its base (plate IX, figure 1).

The Iroquois Shore South of Adams Center

Beginning at the northern end of the town of Adams Center and extending southward through Adams to the southern boundary of the area of study, the Iroquois deposits are quite different from those north of Adams Center. One of the most significant factors which accounts for these changes is the character of the bedrock and the resulting type of surface materials. Whereas the shore to the north of Adams Center followed the steep slopes of the limestone escarp-

ment, the area to the south was chiefly shale, and therefore no steep escarpment confined the lake waters.

The lakeshore at the highest level followed the drumlins and moraines east of U. S. Route 11 between Adams and Adams Center. It is hardly possible to determine the relative influence of wave action and glacial erosion, but a wide area to the west of the high shore has been planed off to form a flat, almost level surface that is everywhere between the 620- and 640-foot contours. It seems that at least the final stages of the leveling were accomplished by wave action when the lake waters were near their highest level. Erosion was therefore very active and for this reason no beach ridges were formed along the shore. Instead, a large offshore bar was built along the western margin of the leveled surface. The offshore bar follows U. S. Route 11 from a point about one-half mile north of Adams Center, through Adams, to the southern limits of the area surveyed in this study. After the offshore bar was built, lake sediments were deposited behind the bar and silt now covers the surface of the area between the bar and the high shore.

The washed-off till, marking the highest level of the lake, is found in a few places along this segment of the shore. This feature, however, is not well developed south of Adams Center and is quite difficult to follow. Elevations were taken at a few points where it is best developed to establish the high water level.

The lower (Frontenac) lake level is not conspicuous between Adams Center and Adams. Between Adams and South Sandy Creek, however, it is well marked by a shore terrace which cuts into the western side of the offshore bar. South of South Sandy Creek the shore is again evident in a large area of washed-off till. This is a boulder pavement par excellence, extending from South Sandy Creek to beyond the southern boundary of the quadrangle (figure 1).

THE LAKE FRONTENAC PROBLEM

As previously noted, the name Frontenac was proposed to designate the lake waters in the Ontario Basin after the Rome outlet was abandoned and drainage shifted to the pass at Covey Hill. The name Frontenac, however, has been given little recognition in the geologic literature of New York State, and it is especially conspicuous by its absence from the writings of Fairchild. The writer has elected to use this designation since it is believed that a distinction should be made between the two lake episodes. It has been customary to assign specific names for different stages in the development of glacial lakes, and this policy has governed the assigning of names in the Great Lakes basins.

This report, therefore, attempts to differentiate between the features of the two lake stages.

The references to Lake Frontenac in geologic literature are most confusing, and efforts to clarify them during this study were not very successful. Since this investigation was concerned chiefly with detailed mapping, it was impossible to include an area large enough to clarify the problem. Certain facts, however, were established which afford a better understanding of the problem.

The chief difficulty in the field during this study resulted from the fact that it could not be established whether the change from the Rome outlet to Covey Pass was accomplished at the highest level of the lake or whether the water lowering took place before the col at Covey Hill was opened. This problem is of utmost importance because, as yet, it is not possible to determine whether the whole sequence of lake sediments was made after the establishment of Lake Frontenac or whether the higher levels represent the Lake Iroquois shorelines. The writer believes that the answers to these questions will be found when a more exhaustive study is made in the vicinities of the two outlets.

It has been assumed that the Rome outlet was abandoned in favor of the Covey Pass because the ice receded enough to free it. Accordingly, the lake waters dropped to a lower level. This drop should therefore be recorded as a definite interval or rapid lowering of the water level. The beach ridges mapped during this survey indicate, however, that the withdrawal of the water from the high level was gradual rather than fast, as would have been true if a lower drainage had been immediately opened.

According to most authorities, the Rome outlet had been uplifted during the existence of Lake Iroquois, and the water level at the time of the shifting of drainage was much higher than when the lake was established. According to Fairchild (1918, p. 27), the Rome outlet was uplifted 180 feet before, and 170 feet after, the extinction of Lake Iroquois. But Fairchild did not make the distinction between the Iroquois and Frontenac levels and, therefore, it is not clear when the uplifting presumably took place. According to Upham (1892, p. 485), the Rome outlet was originally 100 feet or less above sea level and was raised, while in use, to an elevation of nearly 300 feet. Fairchild (1918, p. 64) states that the Covey outlet was at an elevation of 290 feet during the time of its use by the lake. It seems that an uplift of this magnitude could be the cause of the shift in the drainage direction, thereby minimizing the importance of ice recession as a cause of the change.

This investigation concludes that the lake waters dropped from the highest level to one 90 feet lower, and that this withdrawal was gradual enough for definite beach ridges to be formed at various intermediate levels. Whether the drop was accomplished during the time of the Rome outlet or after the shift to Covey Pass is, as yet, undetermined. It seems possible that as uplift occurred at Rome downcutting could have progressed at such a rate as to lower the lake level simultaneous with the uplift and thus account for the beach ridges.

Another possibility that deserves investigation concerns the lake that occupied the Black River Valley during the Lake Iroquois stage. The lake in the Black River Valley at one time drained down the Boonville Gorge to Lake Iroquois. It has been established by former studies that this drainage built a large delta in the vicinity of Rome. It is quite possible that the delta blocked the Rome outlet, and that the water rose to its highest level in order to flow over the delta. It seems that former calculations of uplift might have been based on this type of damming, rather than actual uplift. Downcutting of the delta deposits would therefore account for the gradual retreat of the water.

It is believed by the writer that the lake level of 90 feet below the high water mark was made during the time of Lake Frontenac. This conclusion is in agreement with Coleman (1936a, p. 29) who believes the Frontenac deposits are 50 to 100 feet below the Iroquois shore north of Lake Ontario. It also seems that uplift during both the Iroquois and Frontenac stages was less than heretofore assumed. A possibility which should not be overlooked, however, is that the lake may have stood at its highest level at the beginning of the Frontenac stage. If this were the case, the gradual retreat to the lower level was caused by downcutting at the Covey Pass, and the whole lake sequence mapped during this investigation would have been made during the existence of Lake Frontenac. Under these conditions it might be more appropriate to designate the Covey Pass drainage interval as Iroquois II instead of Frontenac.

Summarizing the foregoing, there appear to be at least two possible explanations for the gradual retreat of the lake waters. First, the highwater level occurred during the Iroquois stage. The water retreated from the high level because of downcutting at Rome, dropping nearly to the level of Lake Frontenac before the pass at Covey Hill was opened. The second alternative is that the uplift of the Rome outlet occurred before the drainage shifted to the north. In this case the abandonment of the southern outlet would have resulted more from uplift than to retreat of the ice. If this were true, the water stood at the high water level at the beginning of the Frontenac stage. It seems that Fairchild

(1918, p. 25) was also thinking of these two possibilities at the time of his report on marine submergence.

UPLIFT OF THE IROQUOIS SHORE

The relative uplift of the area that was covered by Lake Iroquois, and especially the shore of this lake, has been the subject of many prior investigations. Fairchild, in his extensive studies throughout the State, was endlessly trying to solve the problem of the uplifted beaches. The writer, while conducting the survey of the Watertown and Sackets Harbor Quadrangles, was also most interested in this problem. The results of this study, however, do not confirm many of the former concepts concerning diastrophic movements during or since the existence of Lake Iroquois.

The writer believes that two features mapped during this survey add much to the clarification of the uplift problem. In the first place, the highest level of the Iroquois waters and the lower Frontenac level were marked by washed-off till. To the writer's knowledge, this feature had never been considered before, and therefore actual comparisons of the elevation along the shore have never been made. The second clarifying accomplishment made by this survey was that of distinguishing between beach ridges and offshore bars along the shore. The ridges along the shore have been noted, mapped and discussed in many reports, especially in those of Fairchild, but distinction between the beach ridges of the section north of Adams Center and the offshore bars to the south seems never to have been made. With these two new types of evidence as major considerations, the following discussion of the uplift of the shore is made.

The term "high water mark" is here used to denote the highest level of Lake Iroquois. This level was mapped and measured at the top of the washed-off till. Using this feature as a marker, it was found that the high mark along the shore rises from 700 feet in the vicinity of Allendale, two miles southeast of Adams, to 745 feet along the northern slope of the Tug Hill cuesta, three miles east of Watertown. This segment measures 19 miles in a direct distance and 15 miles when measured north and south. The shoreline therefore, has an inclination of only three feet per mile north and south and this is much less than heretofore recorded.

Fairchild (1900, p. 107) states that between Richland and Watertown the shore has an average slope of over five feet to the mile in a direct distance. However, these figures were based only on shore bars and were computed on comparative elevations of the highest beach ridge in the Watertown area and of the offshore bars to the

south. It is interesting to note that Fairchild (1918) recorded elevations on the shore as 622 at Adams, 656 at Brookside Cemetery (two miles south of Watertown) and 671 at Farrs (three miles east of Watertown). The elevation of 622 at Adams was made on the highest offshore bar, but the actual shore was two miles east of Adams at an elevation of 700 feet. The writer does not understand the 656 reading at Brookside, inasmuch as the highest beach ridge at this point is above the 700-foot contour, and the highest shore is 715 feet. The exact location of Farrs is also a puzzle, since none of the Fairchild maps locate it. Since he states, however, that it was three miles east of Watertown, it is assumed that he refers to the beach ridges mapped along the northern slope of Tug Hill. Here the high water level is 745 feet.

Another factor of great concern to Fairchild in his interpretation of the shore was the fact that the shore in some places was higher than he had estimated it should be. For example, in one of his reports (Fairchild, 1918, p. 27) he writes, "The profile of the closing Iroquois shows that from Lacona to Chateaugay, or in the area north of the Rome isobase, there are shore features higher than the lake level." Such problems as these led Fairchild to conclude that certain sections along the shore were uplifted much more than adjacent areas. The writer believes that when the high water level is mapped beyond the boundaries of the two quadrangles surveyed in this report it will be found that the uplift was quite uniform. It should be especially evident when plotted in the direction of the uplift. The shoreline in the two quadrangles of this report is hardly long enough to prove that this assumption is correct.

Another prior conclusion with which the evidence accumulated in this investigation does not agree concerns the differential flooding due to uplift of the Rome outlet. According to Fairchild (1918, plate XII), the rise of the Rome outlet caused no flooding at Adams, but the area three miles east of Watertown was flooded to a depth of 62 feet. If the writer's interpretation of this statement is correct, it means that the uplift at Adams was equal to the rise at Rome, but that the Watertown area was uplifted 62 feet less than Adams and Rome. If true, the vertical distance between the higher Iroquois and the lower Frontenac levels should decrease in the direction of Watertown. This is not the case. The difference in the present elevations of the two water levels is about 90 feet at all points.

It is concluded, therefore, that the uplift of the Iroquois shore was constant. It is also evident that the degree of slope or inclination of the shore line is much less than has heretofore been supposed. Uplifting

in the area during the time of Lake Iroquois seems to have been practically nil, the greater part having taken place after the building of the Frontenac shore.

THE EXTINCTION OF LAKE FRONTENAC

The Lake Frontenac episode came to a close when the Mankato ice in the St. Lawrence Valley melted back sufficiently to allow the lake waters to be lowered to sea level. According to Fairchild (1910, pp. 138-140), the withdrawal of the water was relatively rapid after the removal of the ice dam. In spite of the fact that he recorded the wave-swept surfaces between the Iroquois and Gilbert Gulf levels, Fairchild insists that no shore phenomena exist in this interval. Accordingly, he believed the extinction of the lake was a matter of sudden removal of the ice dam followed by a short period during which the waters escaped without interruption.

If the writer's interpretation of Fairchild is correct, his assumptions allow for no time, during the retreat of the lake waters, for the escape of the waters to be halted or for the lake to maintain a stable level. Such conditions, it seems logical to assume, would cause manifestations or wave action and deposition to be of equal intensity at all levels. That is, if the lowering of the water was uninterrupted, the lake deposits and the wave-washed surfaces should be equally distributed at all levels between the Frontenac and the Gilbert Gulf strand lines. Although the findings of this investigation substantiate the argument that no beach deposits are found in this interval, evidence does not seem to indicate a balance between wave action and deposition at all levels. It is concluded, therefore, that at certain times during the lowering of the lake waters short periods of relative stability did occur. This conclusion is based on the existence of levels in some areas where wave erosion was definitely very severe, whereas in other sections lake deposits occur that were apparently subjected to little or no wave action. The writer deems it necessary, therefore, to make note of these facts in order to point out the possibility of a more gradual withdrawal of the lake waters than has heretofore been assumed.

It is indeed true that there is no elevation or shore level in the entire distance between the Frontenac and Gilbert Gulf levels where manifestations of either lake deposition or wave erosion are completely absent. Both can be found at all levels. This, in a sense, verifies the contentions of Fairchild that the lowering of the lake was rapid and uninterrupted. There are levels, however, which show a predominance of wave action and minor amounts of lake sediments, as well as other levels where these are not found. These facts have caused the writer

Plate VIII

Figure 1. Residual boulders on bedrock surface, two miles southwest of Henderson Bay

Figure 2. Residual boulders concentrated on bedrock surface by wave action of Iroquois Lake episode, two miles southeast of Sackets Harbor

Plate IX

Figure 1. Sandy lake sediments lapping upon the Tug Hill Plateau escarpment. Road cuts across the lake sediments, two miles south of Watertown Center.

Figure 2. Wave-washed bouldery morainic ridge, one mile east of Black River

to believe that the lake waters were temporarily maintained at one or more levels for short periods.

Since all levels contain manifestations of both erosion and deposition, it is difficult to establish elevations that can be definitely designated stable shores. The surface map (figure 1) and field observations seem to show conspicuous difference among the various areas, and for this reason an effort was made during this study to ascertain what levels might represent stability. The most conclusive method used to substantiate the existence of recognizable levels of erosion and deposition was that of making a comparison plot of levels of extensive wave action against levels of deposition. Two different such comparisons were made. First, the elevations of those two distinctly different levels were compared and, secondly, the two phenomena were plotted, using the height of the high Iroquois shore as a basis of comparison. It was supposed that the second method would be more accurate, since comparisons were made along latitude lines in an effort to compensate for uplift.

When comparisons are made of the elevations of the levels of wave action with those of lake deposition over the entire lake plain, it is possible to distinguish levels where one or the other predominates. Lake sediments are definitely more prevalent between the elevations of 250 to 300 feet and 350 to 500 feet, whereas wave action is conclusively more severe between 300 to 350 feet and 500 to 600 feet. It is assumed that the lowest sequence of erosion and deposition represents the Gilbert Gulf episode. This leaves an intermediate sequence, however, that seems to represent a period of relative stability for a short time. As pointed out above, however, the accuracy of this method is readily questioned since uplift increases northward and no correction for this factor was possible.

In an effort to compensate for the error due to uplift, the vertical distances between the highest lakeshore and the levels of erosion and deposition were compared at different latitudes. This method also indicated a shore sequence at the same relative position as that shown by the elevations. This level is marked by an interval of wave action 150 to 250 feet below the highest level of Lake Iroquois. It is doubtful that this marker can ever be more definitely established, even when more detailed studies are completed outside the area of this report.

The most conspicuous evidences for a gradual lowering of the lake waters cannot be mathematically calculated. These manifestations are in isolated areas where wave action was concentrated so effectively that all of the till was removed from the bedrock or the topography was reduced in contrast to other areas where thick deposits of silts

and clay were deposited in the lake and apparently unaffected by waves. For example, it is impossible to survey the area north of Thomas Settlement without noting the residual glacial boulders on bedrock that attest to the removal of a thick till layer. This area also contains expressionless gravel ridges which prove that kamic moraines were greatly reduced. Similarly, the Trenton Escarpment and a wide area of its top, south and east of Sackets Harbor, has been completely stripped and now lies bare with only erratic boulders strewn over its surface (plate VIII, figures 1 and 2).

In contrast to the area where wave action has been so severe, sections such as the one south of Rural Hill indicate that wave action was almost nil, for lake sediments cover even the kamic moraines and drumlins (figure 1). The lacustrine veneer in this area is thick enough to mask completely the compositions of the structures that it covers. Areas of such great contrast as these were found so repeatedly in the area of this study that at least one level of stability during the lowering of the lake waters seems unquestionable.

GILBERT GULF

As previously noted, Lake Frontenac became extinct when the ice that had been blocking the St. Lawrence Valley retreated sufficiently to free the valley and allow the lake waters to drain to sea level. The St. Lawrence Basin was much depressed at this time because of the weight of the glacier, and upon retreat of the ice the valley was below sea level. According to Taylor (1915, p. 326), the sea stood 523 feet higher than it does today or, as Fairchild (1918, p. 64) expresses it, the Covey outlet was 740 feet lower than today, and only 290 feet above the sea. At any rate, when the valley was freed of ice, the sea invaded the St. Lawrence and Champlain Valleys.

Fairchild (1900, p. 157, 158) believed that marine waters expanded to flood the entire Ontario Basin. He named this arm of the sea Gilbert Gulf (Fairchild, 1905). Thus, the term Gilbert Gulf, as proposed by Fairchild, included the so-called Champlain Sea in the Champlain and St. Lawrence Valleys and the supposedly marine waters in the Ontario Basin. The designation Gilbert Gulf is a misnomer, however, inasmuch as it has since been proven that the sea waters did not extend beyond Brockville, Ontario (Lougee, 1953, p. 271). The Ontario Basin therefore remained a fresh water lake during this episode (Coleman, 1936b, p. 73). The name Gilbert Gulf is used in this report, however, to designate the lake waters of the Ontario Basin during the time of the Champlain marine stage in the St. Lawrence Valley.

In the area of this survey, lower shore phenomena, which are believed to be correlative with the Gilbert Gulf Stage, were found only south of Henderson Bay. The best developed segment of this shore is located about one mile west of Rural Hill where a large gravel bar was constructed along the shore of the gulf. Although this bar is composed of gravel with size and appearance more like an offshore bar, it was mapped as a beach ridge because it parallels the shoreline with no indication of a higher shore off which it could have formed. The shore at this point now follows closely the 300-foot contour. This level is much lower than that established by Fairchild (1910, p. 139), but it correlates favorably with measurements made by Coleman (1936b, p. 73) who records the elevations of the Gilbert Gulf shore in Prince Edward County, Ontario, at 325 to 335 feet.

Fairchild (1910, p. 139) states that the entire region immediately north of the Watertown and Sackets Harbor Quadrangles was flooded by the waters of Gilbert Gulf to elevations of 400 to 450 feet. If this were true, the Black River Valley as far west as Watertown would have been flooded (Fairchild, 1910, p. 45), and evidences of shore activities should be found there. Taking into consideration the conclusions of Fairchild, extensive investigations were made during this survey to find manifestations of a shore on this approximate level. No such shore phenomena were found, however, and it is concluded that the waters of the gulf did not rise to elevations higher than 350 feet in the area of this study and were therefore less than 100 feet above the present level of Lake Ontario. It is apparent that Fairchild considered the wave action along the Trenton Escarpment, south of the Black River and extending south-southwest to the southern end of Henderson Bay (figure 1) to represent the Gilbert Gulf shore. The writer cannot completely discount this possibility inasmuch as evidence in this section is not conclusive. It does seem certain, however, that the waters stood below the 300-foot contour at the extreme southern part of the Sackets Harbor Quadrangle, near Lakeview Pond. The wave action along the Trenton Escarpment south of the Black River extends to the 400-foot contour. It seems impossible that differential uplift could have been over 50 feet in this short distance, and therefore the 400-foot marker is believed to be too high to correlate with the gulf.

The shore level here designated as Gilbert Gulf is marked on Pillar Point by extensive washed-off till and wave-washed bedrock containing residual boulders. These occur between elevations of 280 and 340 feet. The same shore is similarly evidenced southwest of Henderson Bay in the vicinity of Hungerford Corners. It is concluded that these mark the greatest extent of Gilbert Gulf in the area of study.

THE LAKE ONTARIO SHORE

Coleman (1936b, p. 73) reports fragmentary beaches between the Gilbert Gulf level and the present Ontario shore. A few small accumulations of gravel west of Gilbert Gulf strand line are probably remnants of a higher shore of Lake Ontario. These are slightly elongate and trend obliquely to the shore. In this area, south of Stony Creek, the bedrock has been uncovered by wave action, and this is also attributed to earlier stages of Lake Ontario. The slope is very gentle toward the lake, and a long narrow sand dune extends parallel to, and only a few tens of feet from, the present lakeshore (plate X, figure 1). The dune restricts drainage, and a swamp has formed behind the dune which extends almost continuously between Lakeview and Black Ponds. The only good, naturally formed beach (Southwick) in the area of study occupies the narrow strip between this sand dune and the lake. Local residents report that the lake level has dropped approximately three feet in the past year or so because of the removal of a dam on the St. Lawrence River. This has resulted in the widening of Southwick beach to almost twice its former width (plate X, figure 2).

The lakeshore north of the mouth of Stony Creek is almost completely void of beaches, and in most sections steep bedrock cliffs rise directly out of the water (plate I, figure 1). In areas where the shore is less steep, beach ridges composed of very coarse limestone gravel line the shore at the water level. Such a ridge is particularly conspicuous along the shore around Pillar Point.

A large accumulation of dune sand borders the lake and extends inland for about 1½ miles in the vicinity of Campbell Point. It is believed that this dune is a quite recent deposit, being associated with the activities of the present lake stage. Another dune area along Muskalonge Bay and extending southwestward to Sackets Harbor, however, is believed to be of earlier age. These dunes surmount a deposit of lake sand which is of Gilbert Gulf or earlier age. The wind action, in most sections, is now dormant. There are, of course, certain localized places where the sands are still shifted about by the wind, but in the main the area is past the active stage.

Black River, Chaumont and Henderson Bays, as explained earlier, are of glacial origin. It seems that the steep walls along most of the lake shore also owe their origin to glacial erosion.

SUMMARY AND CONCLUSIONS

During the Pleistocene Epoch, northwestern New York was repeatedly glaciated by the advancing and retreating Laurentide Ice Sheets. Evidences of the two most recent glacial stages, the Wisconsin

PLATE X

Figure 1. Sandy beach and dunes along Lake Ontario shore, Southwick Beach

Figure 2. Dune sand along Lake Ontario shore, Southwick Beach

and Illinoian, are found in the surface deposits of the State, and it seems probable that a third, the Kansan, moved across this area to reach a maximum that is now recorded in the deposits to the south in Pennsylvania. In the Watertown and Sackets Harbor Quadrangles, however, manifestations of earlier stages were destroyed by subsequent glaciation, and therefore all of the surface materials were deposited by the last, or Wisconsin, ice episodes. Drifts of two different ages were distinguished during this survey.

At the beginning of the last glacial advance in this area and doubtless during earlier advances a segment of the expanding Ontario ice lobe of the St. Lawrence Valley invaded the area of this study from the north-northeast. When the glacier encountered the northern promontory of the Tug Hill Escarpment, the ice was divided into two lobes which moved down either side of obstruction. One of these lobes moved up the Black River Valley and has been named the Black River Lobe. The other lobe moved across the Ontario Lake Plain and is designated the Watertown Lobe in this report. In time, the ice north of Tug Hill thickened sufficiently to move over the escarpment as well, covering the summit of the plateau.

On Tug Hill, the drift is quite thin and the bedrock is reflected everywhere in the surface topography. The glacial drifts north of Sandy Creek were deposited by earlier ice than those to the south of the creek. The absence of an outwash apron beyond the younger terminus is explained by the fact that Sandy Creek served as a border drainage and removed the meltwaters from the area. The position of Sandy Creek, however, is believed to have been established prior to last advance. The Tug Hill drift north of Sandy Creek overlies limestones of the Trenton Group, and the drainage still has an angular pattern due to its recent origin. South of Sandy Creek the drift is composed of shales and sandstones of the Utica and Lorraine formations which it overlies. In this section the drainage has had sufficient time to develop a dendritic pattern.

The Black River Valley section of the Ontario Lake Plain is relatively flat because the Trenton beds were planed from over the more resistant Chaumont Formation of the Black River Group. The channel of the Black River, cutting the Chaumont layers, is of postglacial origin and is very shallow, considering the size of the stream it contains.

South of the Black River Valley, the Ontario Hills section of the Ontario Lake Plain has a surface expression that is quite irregular. The uneven surface is due to bedrock escarpments resulting from the differential effects of ice erosion of the variable Trenton beds. Since the Trenton limestones are interbedded with thin shale layers, glacial

erosion was chiefly a matter of planation along layers weakened by shale partings. The results were the carving of steep-sided, steplike terraces, isolated bedrock remnants and deep channels paralleling the ice direction.

The waters of Lake Iroquois expanded to cover the Ontario Basin and the lake plain in front of retreating ice. The shore phenomena of this lake episode are found along the slopes of the Tug Hill Escarpment between the Black River (east of Watertown) and the southern boundary of the area studied. The highest lake level is marked by a band of washed-off till, formed by the concentration of boulders by the removal of finer sediments by wave action. This high shore now has an elevation of 700 feet at Allendale and it rises gently to an elevation of 745 feet east of Watertown. Between Watertown and Adams Center, a gradual lowering of the lake level from its highest level is recorded by beach gravel and a series of beach ridges. A second stable shore is marked by washed-off till 90 feet below the high water mark, and this level is assumed to represent the Lake Frontenac shore.

Between Adams Center and the southern boundary of the area mapped, the high shore is not well marked. In this section a large offshore bar was built by the action of the waves across a broad, almost level surface. The bar is best developed between Adams Center and Adams, and its position is over a mile west of the highest shore of the lake. Former writers have assumed that this bar was a beach ridge and have calculated the uplift of the Iroquois shore by comparing elevations on the bar with those on beach ridges east of Watertown. The actual rise of the high Iroquois shore in the area of this survey, measured in a north-south direction, is approximately three feet per mile.

The lake plain section of the Watertown and Sackets Harbor Quadrangles has been severely eroded by wave action in many localities. Large areas of bedrock are now exposed, but residual erratic boulders on the surface attest to the fact relatively thick accumulations of till once covered the whole area. Although all levels contain both lake sediments and manifestations of wave action, distribution of these seems to show wave erosion to have been quite severe at various levels whereas lake sediments in other sections and at different levels seem to have been little affected by waves. For these reasons, this study concludes that the lowering lake waters maintained at least one stable level for a shore period between the lower (Frontenac) and the Gilbert Gulf stabilities.

Shore features of the fresh water Gilbert Gulf episode in the Ontario Basin are best developed, in the area of this study, in the extreme

southwestern part of the Sackets Harbor Quadrangle. In this section, the Gulf shore follows closely the 300-foot contour. Although evidence in the northern part of the quadrangle is not conclusive, it is believed that the shoreline is nowhere over 100 feet above the present level of Lake Ontario.

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Figure 1

Figure 1. The surface geology of the Watertown and Sackets Harbor Quadrangles

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of the

NEW YORK STATE MUSEUM AND SCIENCE SERVICE

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MUSEUM BULLETIN NUMBER 370

The University of the State of New York
The State Education Department
Albany, 1958

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The University of the State of New York
The State Education Department
Albany, 1958

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THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of the University

With years when terms expire

1969 John F. Brosnan, A. M., LL. B., J. D., LL. D., D. C. L., D. C. S., Pd. D., *Chancellor* - - - - - - - - - - - - - New York

1968 Edgar W. Couper, A. B., LL. D., *Vice Chancellor* - - - - Binghamton

1963 Mrs. Caroline Werner Gannett, LL. D., L. H. D., D. H. Rochester

1961 Dominick F. Maurillo, A. B., M. D., LL. D. - - - - - - Brooklyn

1964 Alexander J. Allan, Jr., LL. D., Litt. D. - - - - - - - - Troy

1967 Thad L. Collum, C. E. - - - - - - - - - - - - - - - Syracuse

1966 George L. Hubbell, Jr., A. B., LL. B., LL. D. - - - - - - Garden City

1971 T. Norman Hurd, B. S., Ph. D. - - - - - - - - - - - Ithaca

1960 Charles W. Millard, Jr., A. B. - - - - - - - - - - - Buffalo

1965 Chester H. Lang, A. B., LL. D. - - - - - - - - - - - Schenectady

1970 Everett J. Penny, B. C. S. - - - - - - - - - - - - - White Plains

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1962 Edward M. M. Warburg, B. S., L. H. D. - - - - - - - - New York

President of the University and Commissioner of Education

James E. Allen, Jr., Ed. M., Ed. D., LL. D., Litt. D., Pd. D., L. H. D.

Deputy Commissioner of Education

Ewald B. Nyquist, B. S., LL. D., Pd. D.

Assistant Commissioner for State Museum and Science Service

William N. Fenton, A. B., Ph. D.

Assistant Director of State Museum

Victor H. Cahalane, A. M.

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Museum Advisory Council

1958	James L. Whitehead	Staten Island
1959	Harry L. Shapiro	Pine Plains
1960	Hardy L. Shirley	Syracuse
1961	Arthur A. Davis	Rochester
1962	Vincent J. Schaefer	Schenectady

The Staff

State Museum and Science Service

WILLIAM N. FENTON, *Assistant Commissioner*

Anthropological Survey

WILLIAM A. RITCHIE.....State Archeologist, Associate Scientist

Biological Survey

DONALD L. COLLINS.....State Entomologist, Principal Scientist
DONALD P. CONNOLA.....Senior Scientist (Entomology)
PAUL CONNOR.....Scientist (Zoology)
HUGO JAMNBACK, JR.....Scientist (Entomology)
EUGENE C. OGDEN.....State Botanist, Associate Scientist
RALPH S. PALMER.....State Zoologist, Associate Scientist

Geological Survey

JOHN G. BROUGHTON.....State Geologist, Principal Scientist
DONALD W. FISHER.....State Paleontologist, Associate Scientist
WM. LYNN KREIDLER.....Senior Scientist (Geology)
JAMES N. BOWERMAN.....Junior Scientist (Geology)
LAWRENCE V. RICKARD.....Senior Scientist (Paleontology)
Vacant.....Scientist (Geology)

State Museum

VICTOR H. CAHALANE, *Assistant Director*

Curatorial

CHARLES E. GILLETTE.....Associate Curator (Archeology)
CLNTON F. KILFOYLE.....Associate Curator (Paleontology)
EDGAR M. REILLY, JR.....Associate Curator (Zoology)
STANLEY J. SMITH.....Associate Curator (Botany)
JOHN A. WILCOX.....Associate Curator (Entomology)
KURT SERVOS.....Senior Curator (Geology) (Resigned 6/19/57)

Exhibits

WALTER J. SCHOONMAKER.....Museum Exhibits Planner
LOUIS J. KOSTER.....Senior Museum Technician

School Services

RUTH RUBIN.....Museum Education Supervisor

At an evening reception for several hundred guests to preview the special exhibit, "The Four Kings of Canada," Governor Averell Harriman greeted two delegates from the Six Nations, Mohawk Councilors Joseph Hill and George Buck of Brantford, Ontario.

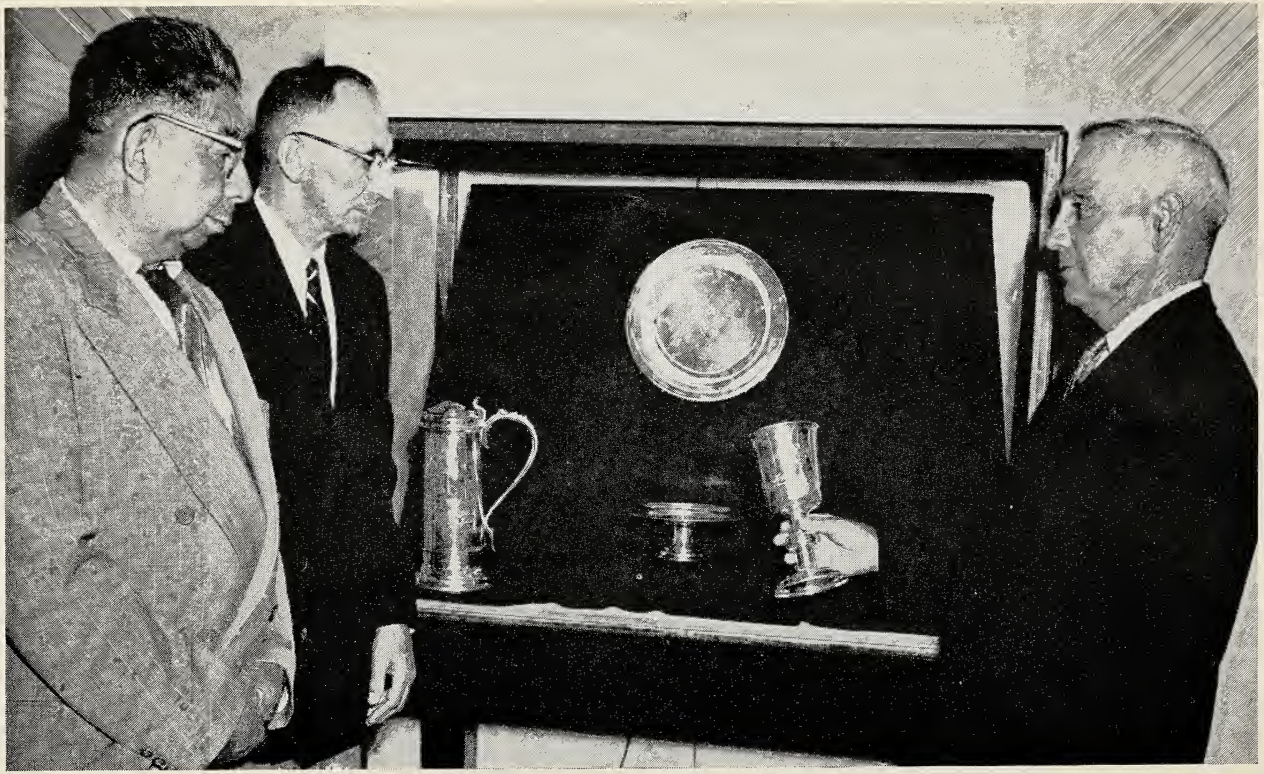
General Statement

I HAVE THE HONOR TO SUBMIT a summary report of the major activities and accomplishments of the New York State Museum and Science Service for the year ended June 30, 1957. In line with the action of the Board of Regents in September 1955 on a proposed reorganization, reports of research accomplished are grouped under the Anthropological, Biological and Geological Surveys, respectively, as are the related curatorial activities in the Museum, while the interpretive activities in exhibits and education are reported under the Museum.

The year was marked by significant advances in research and by a noticeable speedup in the exhibits program. Our leadership in research was recognized by both private and public grants in aid of research in addition to regular Departmental funds. Mr. Ward Melville of Stony Brook, Long Island, made an initial grant for archeological exploration of a village site at Stony Brook, Long Island, and a subsequent grant for the publication of the report by the State Archeologist. Dr. Ritchie was also awarded a National Science Foundation grant in support of a study of aboriginal settlement patterns in the northeast for a period of three years. At the close of the year, the State Botanist received a substantial grant from the National Institutes of Health toward allergy studies, a field in which he has made significant contributions.

No single museum exhibit held in Albany in recent years has attracted wider notice than the exhibit on the "Four Kings of Canada" which was sponsored jointly by the State Museum and State Library in September and October. The exhibition was staged in honor of the International Congress of Anthropological and Ethnological Sciences which met that September for the first time in America and it coincided with International Museums Week of UNESCO. The happy combination of events enabled the two cultural institutions of the Department to assemble for the first time in Albany since 1712 objects of Indian manufacture left by Mohawk Indians in London, notices of their visit to the Court of Queen Anne, the silver plate which the Queen sent to commemorate their visit in 1710, the city's portrait of Peter Schuyler, the first mayor of Albany, and living representatives of the Six Nations of Canada. Both the Governor and the Commissioner honored the opening which was marked by a reception in the Museum and the Library.

The permanent exhibition program made a bold advance in the removal of the mastodons from the Rotunda area to the east end of



For a special exhibit entitled, "The Four Kings of Canada," the Six Nations loaned the silver communion service which was presented to Her Majesty's Chapel of the Mohawks by Queen Anne in 1712. Accompanying the silver from Brantford, Ontario, were (left to right, above) Councilor George Buck (Split-water), Chief Councilor Clifford Styres and Councilor Treasurer Joseph Hill.

Paleontology Hall, freeing a large area in which to greet visiting school groups. The new Orientation Hall is flanked by new exhibit cases, each of which will summarize a subject area in a larger hall. In the center of the room the school children's old favorite, the relief map of New York, has been converted from an out-dated geological map to an up-to-date vegetational map of the State; and in the east end of the Hall of Ancient Life, Edwin W. Becker, Albany artist, has executed one of the largest mural paintings in Albany, depicting the end of the Ice Age in the Catskills where the mastodon roamed 10,000 years ago. Mr. Becker's arresting mural was done after a water color rendering by Roy M. Mason, N. A., of Batavia, who donated his services.

The acceleration of the exhibits program followed a national survey of museums by the Assistant Director. In the previous year, Mr. Cahalane had toured western museums, studying every phase of their activities from the care of collections to their interpretation and observing the reactions of the visiting public to the exhibits. This year his notebooks and photographic albums were opened to a broader field when he and the Assistant Commissioner visited museums in the southeastern United States, heeding especially the reaction of New York taxpayers to attractions outside their State.

This trip had two results: The first was a report with recommendations which was first discussed at the meeting of the Museum Advisory Council on April 26, revised in the light of that discussion and commended to the appropriate committee of the Board of Regents for its attention. The same statement provided the foundation for drawing up program goals in cultural areas for the Commissioner's staff conference at Cooperstown in June. The Assistant Commissioner wrote and delivered the general statement as well as the statement on the Museum and Science Service.

Secondly, seeing other laboratories in museums, governmental establishments and universities helped in planning laboratory space for the Science Surveys and enabled the Department to convince State officials that research laboratories require different space modules from administrative offices. The scientists gratefully acknowledge the confidence of the Departmental building committee in awarding us the ninth floor of the Annex.[1] These negotiations entailed numerous conferences here in the Department and with officials from the Department of Public Works. During the same year the State Architect's office vetoed the proposed use of the light wells above the State Library for storage and exhibition purposes. Perhaps the most rewarding return of the survey was the chance to

[1] The Annex refers to the projected 10-story addition to the State Education Building in Albany.

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discuss with professional colleagues the organization of museums, the conduct of research, the relation of research in the natural sciences to teaching in universities and to adult education generally.

Toward improving communication within the Department, the Assistant Commissioner held regular monthly staff meetings a week following the Commissioner's staff meetings. These sessions enabled the staff to meet Departmental officials, to report informally our research interests to the Division of Research, to improve our public relations and to bring the staff up-to-date on State travel regulations.

A number of staff changes occurred during the year. On October 15, Mrs. Marjorie Schmidt reported as principal clerk and steps were taken to organize the clerical and fiscal affairs on a more efficient basis with a view to facilitating communication with the business office. The Biological Survey became a reality with the reclassification of Donald L. Collins to principal scientist (Biology), placing under his jurisdiction the scientific work in Botany, Entomology and Zoology. Two new line item positions were added to the staff, one in each area:

Scientific aide (Botany).....Donald M. Lewis
Scientist (Entomology).....Hugo Jamnback, Jr.

The employment problem in geology continued critical. The position of senior scientist (Geology) has remained vacant since John James Prucha resigned on June 1, 1956. He was followed by John A. Graham, scientist (Geology), who resigned January 3, 1957. The position of senior scientist (Paleontology) was filled August 16, 1956, by Lawrence V. Rickard, formerly of St. Lawrence University. The new position of senior curator (Geology) was occupied from September 27, 1956, until June 19, 1957, by Kurt Servos, who came to us from Yale University and left to teach at Stanford. James M. Bowerman joined our staff in the Wellsville office February 14, 1957, as junior scientist (Geology). The full-time position of museum instructor was vacant until May 23, 1957, when it was filled provisionally by Miss Barbara Alberts.

The Assistant Commissioner gave a great deal of time to planning and design of research, to visiting field projects with supervisors and to reviewing research results. An innovation was achieved in planning and executing an ecological survey of the Allegheny Reservoir which represented the first integrated research by a team of scientists representing several branches of the Service. It is anticipated that a report on the Allegheny Project will be helpful in formulating State policy on a public issue.

The archeological program of the Anthropological Survey reported below was expanded and supplemented with work on the Seneca lan-

guage. The Geological Survey has given increased attention to compiling a new State geologic map which it is hoped for the first time in 50 years will meet a need expressed by geologists and engineers for information on vital resources. The work of the Biological Survey remains heavily concentrated in entomology. Some balance was achieved by expanding the work in zoology. The small mammal survey was started cooperatively with the Interdepartmental Committee on Rabies. The researches of the State Botanist on pollen were augmented by hiring temporary assistants.

The Assistant Commissioner's role is largely administrative. He served the Department on the Management Advisory Council, chaired the Subcommittee on Natural Resources and Natural Sciences of the Interdepartmental Committee on Research, represented the Department on the Governor's Committee on the Utilization of the Thomas Indian School which entailed making several trips to western New York and attending meetings in Albany. He also served on the Alexander Hamilton Bicentennial Committee, securing a portrait for the Regents Room. His office conducted the Heart Fund drive for the Department.

In the course of a year the State Museum attracts some distinguished visitors. They came during the year 1956-57 from nine foreign countries including Africa and the U. S. S. R. From New Zealand and Africa three colleagues were sent to us by the Carnegie Corporation of New York.

There was also the Monday when a bomb scare brought the State Police in numbers to our floor. Though the word "bomb" had been chalked on a switch box panel and the Police apprehended two suspects, some alert Boy Scouts had observed the writing on the previous Friday and were able to provide an alibi. And Monday is usually a dull day in the State Museum!

The Assistant Commissioner's diary notes 12 major items of advice. These range from helping the Columbia Broadcasting Company and NBC's program "Wide Wide World" to assisting the trustees of the Montgomery County Historical Society on the disposition of an Indian collection from historic Fort Johnson. A second list would include 17 talks given by the Assistant Commissioner to New York audiences, two on the program of the Museum and Science Service, and the rest on some phase of his specialty, the Indians of New York, to audiences ranging from the Girls Academy in Albany to the Graduate Anthropology Club of Columbia University. A professional responsibility which he brought to the State Museum was discharged toward the Vth International Congress of Anthropological and Ethnological Sciences, of which he was secretary-general, when it met in Philadelphia in September. The Hiawatha wampum belt was adopted as the emblem of the Congress

and an explanatory paper will be published in the Proceedings. Besides, he organized and chaired the 10th Conference on Iroquois Research at Red House and participated in the Department's seminar on intergroup relations at Pawling.

It would be remiss not to mention the improved publications position of the State Museum as reflected in the bibliography of its staff. The Department's support has been a vital factor, but the steady flow of publishable manuscripts depends on the vigorous prosecution of a policy which holds that the taxpayer's dollar is returned when the report of research accomplished is printed. Because no official press can possibly handle the writing of an alert staff of scientists, a Journal Series was instituted for releasing and officially recording articles published outside. Though not every man can publish in a given year and the titles listed by some would indicate that they are industrious, the larger works are a number of years in preparation and a productive scientist may appear silent on the record for a limited period. One scientist, for example, has been working steadily on a handbook of worldwide importance in his specialty.

William N. Fenton

Assistant Commissioner for
State Museum and Science Service

Accomplishments of the Surveys

Anthropological Survey

THOUGH SMALLEST OF THE THREE SURVEYS, the work in anthropology has aroused public interest and attracted the first outside support. The Ward Melville grants and the support by the National Science Foundation have enabled the State Archeologist to intensify exploration of prehistoric Indian settlements. To the work on prehistoric peoples has been added studies of their living descendants.

The State Archeologist reports on fieldwork accomplished: Major projects, undertaken and completed were confined to Long Island, where definitive work was done on two sites of the Orient culture (Stony Brook and Sugar Loaf Hill) and one site of the earlier Archaic period (Wading River). A report combining the studies on all three sites (plus our 1953 work on the Orient culture site at Jamesport, Long Island) is in press.

Salvage excavations were undertaken at Honeoye and Brewerton. At the former, significant data were collected and a report compiled for subsequent publication.

Laboratory Analysis

The materials and other data from the following sites were analyzed and the results incorporated into reports for publication: Stony Brook, Wading River, Jamesport, Sugar Loaf Hill, South Cruger Island, Bannerman, Lotus Point, Van Orden, Greene Point.

A new set of archeological culture sequence and chronology charts for New York State was prepared.

Office Activities and Administration

One hundred sixteen local or out-of-town visitors, including 12 professional colleagues and 14 students, came with problems or for information for use in papers, 7 came for advice regarding a career in archeology or anthropology and 27 amateur archeologists sought help with techniques or interpretation of their sites.

Dr. Ritchie and the Assistant Commissioner conferred with officials of the Federal and State Highway Departments concerning a program for Highway Archeological Salvage and prepared draft of proposed antiquities law for New York State.

A team of State Museum fieldworkers, the Curator of Botany (left) and a Graduate Student in Ethnology, interview a Seneca Indian to obtain information on the identification, locality and uses of **Ipomoea pandurata** *L., Seneca "Man Root." The inquiry occurred during a comprehensive study of the geology, botany, zoology and anthropology of the Allegany Indian Reservation which was undertaken in June 1957.*

Dr. Ritchie handled official correspondence and correspondence as president of National and State archeological societies; he supervised investigations of P. P. Pratt in Oneida Indian studies; furnished information to about 20 newspaper or other news agency communications; wrote two articles for "Notes and News," an editorial, and a letter in tribute to Dr. E. A. Douglas for *American Antiquity;* item for *Teocentli,* and an article on New York archeology for the *American Peoples Encyclopaedia Year Book.*

Cooperative Work

Five groups of amateur archeologists heard lectures by the State Archeologist; officials of various organizations sought his help—Nichols Pond Association, Roberson Memorial Center, amateur archeological groups—regarding problems of research, exhibition and techniques. He identified two sets of human remains for New York State Police Laboratory.

Professional activities included presiding and giving a paper at annual meeting of Society for American Archeology at Madison, Wis., and the annual meeting of New York State Archeological Association at Rochester; giving a paper at annual meeting of American Association for Advancement of Science, New York City, at the annual meeting of Eastern States Archeological Federation in Trenton, N. J., and citing the Viking Fund Medalist, Society for American Archeology, New York City.

A study of the Seneca Indian language, an important dialect of the Iroquoian family still spoken in New York, was commenced by Wallace L. Chafe, a graduate student at Yale University under the direction of Prof. Floyd G. Lounsbury with a view to exploring the relations between first speaking an Indian language and progress in school. Beside working out the structure of the language with native informants, Mr. Chafe tested children in two Indian schools and prepared a report of his findings.

Cambridge University sent a graduate student, Mr. Merlin G. Myers, to the State Museum to prepare himself under our guidance for fieldwork on the political organization of the Six Nations Reserve in Canada, an investigation which enabled us to get comparative material on the same problem in New York. Likewise, Miss Cara B. Richards of Cornell University completed a study of health and education on the Onondaga Reservation and submitted two reports for use in the Department and in the Department of Health. Her fieldwork was supported by the Graduate Student Honorarium program.

Biological Survey

Each office of the Biological Survey engaged in one or two major activities on which relatively large amounts of time and effort were spent, and also carried on other projects on which less emphasis was placed.

In Botany, several aspects of the study of pollen received special attention, as described in greater detail below. In addition, the final steps were taken to activate a three-year project involving the radioactive tagging and sampling of ragweed pollen. Through the agency of the National Advisory Council on Allergy and Infectious Diseases, a grant was made to the State Botanist for this purpose by the National Institutes of Health. The studies will be made at the Brookhaven National Laboratory.

In Entomology, active fieldwork was in progress on nuisance insects and forest insects. In the former field, work on the salt-marsh greenhead (a biting fly which attacks man) was brought to the point where a bulletin is being prepared to describe the findings in biology and control. At the same time, more intensive work on sandflies was begun, with the same cooperator, namely, the Suffolk County Mosquito Control Commission.

In the forest insect work, the white pine weevil and the gypsy moth continued to be the subject of special studies, and forest plantation insect problems in general came in for a large share of attention. These studies are made in active cooperation with the Bureau of Forest Pest Control of the Conservation Department.

In Zoology, work on a continuing, long-term project, a *Handbook of North American Birds*, to be published in five volumes, occupied the major portion of time of the State Zoologist. In addition, the Zoology office continued its small mammal survey, which includes the taking of data of special interest in the study of rabies.

Details of the projects mentioned, and of others, are given below.

Field Research by Projects

Botany Project No. 1. Aquatic plant fragments: their identification from anatomical characters.

Although tiny fragments of stems of water plants have diagnostic anatomical characters allowing their determination to genus and perhaps to species, they have never been investigated systematically despite

potential value of the resulting knowledge to wildlife and fisheries management. Research in this field was started and about 75 samples were collected; they are now awaiting histological treatment. Each sample of fragments was matched by a herbarium sheet of corresponding origin. Both types of collection can be used for permanent reference.

Botany Project No. 2. Survey of airborne pollen grains and fungus spores.

The pollen survey, begun in 1952, was completed and discontinued and the last of the 36 field stations was dismantled. Also, the last 6,000 or so of the 15,000 samples collected (which required 2,500,000 identifications) were processed. Now all the data are on IBM cards. The final processing is done by the Bureau of Statistical Services of the Education Department. More than half of the 80 graphs that will constitute the total have been made, about 20 having been done during the past year. Incidentally, it requires about a week to prepare one graph, including analysis of the work sheets. A preliminary report, covering the 1953 data has appeared (Ogden, 1957).

Botany Project No. 3. Ragweed pollen in the air, in relation to weather conditions.

Growing out of the pollen survey, this project, begun in 1955, is being conducted in collaboration with the Meteorology Group, Reactor Department, Brookhaven National Laboratory. It is designed to determine the amounts of ragweed pollen in the air at different heights, at different times of day and under different weather conditions. Samplers were constructed and operated at different heights up to 355 feet on a 420-foot tower. A "standard" type of sampler (the Durham) was used and a modification of it was developed last year to overcome some of the objectionable features of the older one. The data thus far obtained seem to indicate less difference due to height than is commonly supposed, within the levels studied, but there are large variations due to wind velocity and orientation of the sampler. Work on two papers setting forth the results to date was begun.

Botany Project No. 4. Pollen spectra of bog and lake sediments.

What was the floristic and climatic history during the last 10,000 years? Can it be correlated with archeological culture studies? If so, we can supplement data gathered by geologists on relative ages of various glaciated areas and supply data to the Conservation Department on forest development.

The studies have been begun on a very modest scale to perfect and test the sampling equipment, which is being made at Philip Schuyler High School under the direction of Herbert M. Mapes, director of vocational education for the Albany Public Schools.

One hundred collections of known pollens, backed by herbarium vouchers, were added to the pollen file in anticipation of studies on lake sediment spectra and honey pollens.

Botany Project No. 5. Checklist of the grasses of New York.

Approximately 600 specimens were collected, with field notes giving a grand total of 625 new distribution records. The work on the checklist is 95 percent completed.

Botany Project No. 6. General survey of the vascular plants of New York State.

Observations and collections were made in 32 counties, yielding new records on approximately 1,500 species and subspecies of vascular plants. This project is about 75 percent completed.

Botany Project No. 7. Checklist of the mosses of New York State.

This checklist has been in manuscript form for some time awaiting publication. The delay allowed time for the incorporation of a few records which had been added; the manuscript has been returned to the Department editor.

Botany Project No. 8. The Desmidaceae of the Susquehanna drainage in New Yok State.

Fieldwork has been completed and identification of the collected specimens is in progress.

Entomology: Projects on forest insects.

The Entomology office has had work under way on a number of projects having to do with forest insects, most of which are carried on in cooperation with the New York State Conservation Department.

There are roughly three types of projects: (A) a study plot type project (biology and ecology) where conditions are noted each year during one or more definite seasonal periods to determine what conditions cause specific insects to spread or increase, or to die out or disappear; (B) survey type, where the distribution or relative abundance of certain insects, throughout the State, are reported and studied, and

(C) control research studies, undertaken when an insect reaches outbreak proportion in a wide area, or where a potentially or actively dangerous insect occurs in sufficient numbers in limited areas to make control necessary, or where the studies will furnish especially desired information.

The 11 principal projects on which data were obtained are as follows:

1. *Beech scale.* The sixth year in a 10-year program

2. *European pine shoot moth.* No further work except observation is contemplated on this insect in 1957.

3. *Forest tent caterpillar.* It is expected that the summer of 1957 will see the end of these studies, at least for the present.

4. *Gypsy moth studies.* (*a*) Control. Examinations were made of trees in a preseason airplane spray test plot, in which fish oil had been added to the DDT spray to determine whether the effects could be prolonged, making earlier sprays feasible. This would avoid the residues on forage crops which might occur from late DDT sprays. Results were not favorable. Therefore, the following season (spring of 1957) malathion was tried, at half a pound and one pound per acre. On the basis of these tests, malathion appears quite promising as of the present writing, although all results are not yet available and a sufficiently comprehensive range of dosages has not yet been tested.

(*b*) Gypsy moth study plots. Data were collected from 12 gypsy moth study plots in the Lake George area in the summer of 1956. These data form the background and basis for studies that are now being made in more detailed fashion by a temporary science research expert assigned to the project. He began his observations on June 20, 1957. It is hoped to develop information that will assist in planning control measures that will avoid some of the dangers and other drawbacks of those that are currently employed.

5. ***Ips pini*** *and log treatment tests*

6. *Red pine sawfly*

7. *Silvicultural practices in relation to insect attack in forest plantations*

8. *Soils and sites, their relation to tree health and susceptibility to insect attack.* It is believed that many of our insect problems are a result of poor tree growth and poor vigor, originating from soil conditions.

9. *Matsucoccus scale of red pine*

10. *Miscellaneous forest insects. Birch leaf miner*

11. *White pine weevil*

Entomology: Projects on nuisance insects and insects of public health importance

12*a*-13*a*. *Tabanus* (greenhead flies) and *Culicoides* (sandflies): (*a*) Rearing and identification. Larvae of both of these groups, in which there is much taxonomic and biological confusion, were collected and reared and keys were worked out.

12*b*. *Tabanus* (greenhead fly) control. Two plots, of about 105 and 232 acres respectively, were treated by helicopter with 2.5 percent dieldrin granules at the rate of 0.3 pound technical material per acre. The larval population was greatly reduced in both plots. In the smaller plot, which consisted of an entire, isolated salt marsh, the larval reduction was reflected in reduced adult populations. In the large plot, which was contiguous with untreated marsh, the adult population remained high.

Variations and improvements suggested by the work of the summer of 1956 were made and additional treatments were applied in the spring of 1957. As of July 1, 1957, these were being evaluated.

13*b*. *Culicoides* (sandfly) control. Larval sampling methods were developed and small scale experimental control tests were made. Studies of the seasonal abundance of the annoying adults were made. Effective work on control has had to await the solution of some of the biological and taxonomic problems (see above) and the development of sampling methods.

14. *Blackfly control research.* The blackfly work in 1956-57 included (1) several trips through the Adirondack blackfly areas prior to the first sprays in order to determine when the treatments should be made and (2) a trip between the first and second sprays to evaluate results in terms of larval control and (3) a trip after the last spray to evaluate practical blackfly abatement.

It was found that in spite of special attention to the Tahawus area, where we have had a collaborator taking detailed data, in both years there was a period of 3 or 4 days in June when the flies were objectionably abundant. Special work is needed to determine the cause of this flaw in an otherwise good picture.

Zoology Project No. 1. Small mammal survey.

This project was carried on, as in the past, with the cooperation of the State Department of Health and the State Conservation Department. From June 20, 1956, to April 1, 1957, headquarters were maintained in Otsego County. In the spring of 1957 headquarters were

transferred to Richmondville, Schoharie County, another area of high rabies incidence.

Most of the collecting early in the period was done in Gilbert Lake State Park and in the vicinity of Otsego Lake, with other points of the county trapped less intensively. The Otsego County activities comprised a total of 15,302 trap nights. Of the 1,589 animals collected in the project through March 31, 1957, 1,450 were taken by trapping. These yielded 328 skins with skulls and 69 whole skeletons. In addition there were over 50 specimens preserved as separate skulls without skins.

Brains of over 800 specimens of shrews, moles, bats, squirrels and mice were removed, preserved and supplied to Dr. R. L. Parker in the continuing rabies study. In many instances stomach contents, parasites and other items were also preserved.

In addition to the above data, weights, measurements, reproductive data, ecological data and notes on animals other than those collected were recorded.

In the rabies studies made in connection with the small mammal survey, 890 specimens from 18 genera were used. No rabies was detected in any of these specimens.

After transferring the headquarters to Richmondville, a small trapping effort in Greene County yielded 69 specimens. Detailed data from Schoharie County have not yet been compiled.

Office Activities and Administration

Biological field projects are especially active in the early spring, through the summer and into early fall. Although they may appear to go into a period of relative dormancy through the winter, this "dormancy" is more apparent than real, for it is during this period that much of the laboratory work and office work is done, including the preparation of histological and museum material, the compilation of data, comparison of records and writing of manuscripts for publication. It is also the busy season for scientific meetings and planning for the next field season.

One of the major projects of the Biological Survey is the Bird Handbook Project. It will require a number of years for completion. However, tangible progress and accomplishment can be reported:

1. Assigning appropriate authors
2. Completing and publishing the color standard
3. Receipt of manuscripts
4. The establishing of deadlines

Collaborating authors and agencies numbered some 50 names.

A noteworthy event was the loan from the Canadian Wildlife Service of 42 unpublished reports.

Laboratory Work by Projects

Laboratory work was an essential feature of most of the field projects already described. Projects in which the laboratory work occupied an especially large share of the time included:

Botany No. 2. Microscope work to make identifications of material from the 15,000 field-collected pollen samples entailed 2,500,000 identifications during four years.

Entomology No. 8. Soil samples were brought into the laboratory and studied to determine certain chemical and physical properties, to be correlated with field notes on conditions of trees with respect to general health and insect attack.

Entomology No. 12 and No. 13. The rearing of *Tabanus* and *Culicoides* larvae. The mounting of specimens and parts of specimens, and the dissections and examinations, on which the keys were based, occupied a large part of the winter.

Conferences and Meetings

Dr. Ogden, Mr. Smith and the Assistant Director attended the meetings of the American Institute of Biological Sciences at Storrs, Conn., where Mr. Smith read "The Problem of Chromosome Numbers and Conservative Species" before the American Fern Society. The two Botanists participated in the second annual Mycological Foray at Croghan in October and the third annual Mycological Foray in the Huntington Forest, near Newcomb, in June. These forays are cooperative undertakings involving botanists from the State University colleges, the Eastern New York Botanical Club and eastern Canadian institutions.

Mr. Smith directed a field trip to the Adirondacks for registrants at the Summer Institute for Teachers of Botany, a National Science Foundation Institute, sponsored by the Botanical Society of America, at Cornell University.

The entire scientific staff of the Entomology office attended the 10th International Congress of Entomology held at Montreal in August 1956. The work described in their papers has attracted worldwide attention. They also participated in the annual meeting of the Entomological Society of America in New York City in December.

Other meetings attended were: (1) Society of American Foresters in Syracuse (Connola), (2) Northeastern Forest Pest Council in Boston, Mass. (Collins and Connola), (3) Northeastern Mosquito Control Association, Providence, R. I. (Jamnback and Collins), (4) The American Mosquito Control Association in Miami, Fla. (Collins).

Dr. Jamnback was elected vice president of the Northeastern Mosquito Control Association. Dr. Collins continued as editor of *Mosquito News*, the journal of the American Mosquito Control Association.

The State Zoologist attended the annual meeting of the Wilson Ornithological Society in Buffalo in April and the annual meeting of the American Institute of Biological Sciences at Storrs, Conn., in August. At a sectional meeting of the affiliated Ecological Society of America, he read a biographical account of the late Dr. C. C. Adams, onetime Director of the State Museum. In September he attended the annual meeting of the American Ornithologists' Union in Denver, Colo., to report to the Council on the Handbook of North American Birds. In November he attended the annual meeting of the National Audubon Society in New York City. Dr. Palmer and Dr. Reilly represented the organization at the opening of the new Ornithology Laboratory at Cornell University in May. On March 12, 1957, Dr. Palmer attended the annual meeting of the Linnaean Society of New York in New York City.

Student Honoraria

The following student honorarium recipients reported on their work:

B. Collette ($200) Life history of the swamp darter. (Zool.)

H. Klein ($300) (A renewal) Ecology of deermice. (Zool.)

J. New ($100) Marking small mammals with dyes. (Zool.)

R. Stein ($100) Biology of the alder flycatcher. (Zool.)

D. Cox ($200) Pollen spectra in New York State bogs. (Bot.)

Cooperative Work

Each office of the Survey deals directly with the public on matters within its purview. In Botany, telephone calls and correspondence included requests for information on pollen-free areas and weed control, as well as information on plants in general. In Entomology, calls and correspondence related chiefly to household insects, structural pests such as termites, insect pests of forest and shade trees, and numerous insects including blackflies and mosquitoes. Considerable time was saved by preparing in advance short, typed informational circulars, so that they

could be sent out in answer to the questions. In some instances circulars from the U. S. Department of Agriculture and from the State University College of Forestry were sent out in answer to questions. The late spring apparently resulted in more birds and animals being seen by more people than usual, as evidenced by an increased number of telephone calls received in Zoology asking for information on the specimens seen. State agencies which frequently submitted specimens for identification and advice were the New York State Department of Health, the Conservation Department, the Department of Agriculture and Markets and occasionally the Department of Public Works. Many specimens were brought into the Entomology office by Pest Control operators. In all, about 300 requests for information on insects were received and answered in the Entomology office.

Many of the Science Service projects depended upon the active participation of one or more collaborating agencies, as follows:

Pollen survey: Bureau of Statistical Services, New York State Education Department; Division of Laboratories and Research, New York State Department of Health.

Ragweed pollen in the air: Meteorology group, Reactor Department, Brookhaven National Laboratory.

Pollen spectra of bogs and lakes: Philip Schuyler High School, Vocational Education Department.

Forest Insect Projects: Bureau of Forest Pest Control and other bureaus of the Division of Lands and Forests, New York State Conservation Department; American Cyanamid Company; United States Forest Service; State University College of Forestry at Syracuse; State University College of Agriculture at Cornell University; State University Agricultural and Technical Institute, Farmingdale, and the Boyce Thompson Institute for Plant Research.

Nuisance Insects and Insects of Public Health Importance: Suffolk County Mosquito Control Commission; Long Island State Park Commission; Town of Webb; National Lead Company; United States Fish and Wildlife Service; New York State Department of Health, Division of Laboratories and Research; Tuckahoe School District.

Bird Handbook Project: American Ornithologists' Union; 50 ornithologists and ornithological agencies.

Small Mammal Survey: New York State Department of Health, New York State Conservation Department, Gilbert Lake State Park Commission, The Farmers' Museum, Cooperstown, State University Agricultural and Technical Institute at Cobleskill.

Professional Activities of the Staff

During June and July, Dr. Ogden was on leave to teach at the University of Minnesota summer session. He also lectured on the survey of airborne pollen before the Eastern New York Botanical Club and before the Sigma XI Society.

Dr. Collins and Mr. Connola, at the request of the Bureau of Forest Pest Control, Conservation Department, attended the annual meetings of the district foresters and fieldmen to answer questions.

Dr. Collins continued to act as editor of *Mosquito News*, the official journal of the American Mosquito Control Association. He also continued on the advisory board of the Northeastern Mosquito Control Association and continued as a member of the Northeastern Forest Tree Improvement Committee and as a member of the Northeastern Forest Pest Council. Dr. Jamnback became vice president of the Northeastern Mosquito Control Association.

Mr. Wilcox conducted field classes in insect study for the fifth and sixth grades of East Greenbush school and lectured on the taxonomy of beetles at the State University College for Teachers at Albany.

Dr. Collins gave two lectures on garden insects to garden clubs, one in Loudonville, one in Ravena, and a lecture on ticks and other ectoparasites in Amsterdam.

Dr. Palmer was elected to the Council of the American Ornithological Union, and continued as scientific adviser for the E. N. Huyck Preserve in Rensselaerville and to the Federation of New York State Bird Clubs.

Dr. Reilly visited the American Museum of Natural History to identify and compare bones of pleistocene mammals uncovered in the State. He lectured on birds of New York before the White Plains Garden Club and made 14 appearances locally before schools and clubs to give talks on birds and animals. He also instructed two sessions of the Conservation Department workshop, at Alps, N. Y., in September, and gave a talk on the biological sciences on "Career Day" at Chatham Central School.

Geological Survey

The past year has seen the published results of a number of research projects which were supported in the recent past. Manuscripts have also been submitted for publication which summarize additional researches.

Two major projects now completed deserve special mention.

a. An eight-year study of the geology of the Paradox Lake, Ticonderoga, Elizabethtown and Port Henry quadrangles by Matt

Walton and John Rodgers of Yale University, was terminated. The maps have been completed and a report which is now being written will contribute greatly to the understanding of the origin of the rocks and ore deposits of the eastern Adirondacks.

b. Two reports have been submitted by Paul MacClintock of Princeton University, and associates, who were employed as temporary experts to study the glacial geology and surficial deposits of the St. Lawrence Valley and of the St. Lawrence Seaway and Power Projects. These preliminary reports have been in great demand by the authorities and engineering concerns engaged in construction of these major engineering works, and the foresight which went into planning, undertaking and completing this research in time for its practical use has earned wide notice.

Field Research

Because the reporting period encompasses portions of two field seasons, it will be necessary to list these by fiscal years.

1956—57

The survey of limestones in New York State was carried on at a reduced scale. Two months' fieldwork during the 1956 field season was carried on by John H. Johnsen of Vassar College, assisted by Samuel Stevens of Syracuse University. This field season saw the completion of geologic fieldwork in Jefferson County.

Matt Walton of Yale University completed the fieldwork of a four quadrangle (Paradox Lake, Ticonderoga, Elizabethtown and Port Henry) area in the Adirondacks. He was assisted by Benjamin Berry.

Paul MacClintock of Princeton University, though not employed by the State during the 1956-57 field season, was in the field through the courtesy of the engineering concerns working in the St. Lawrence area. During the winter of 1956-57, he and David P. Stewart of Miami University reported on the Pleistocene geology of the St. Lawrence Valley and MacClintock reported on the engineering geology of the St. Lawrence Seaway and Power Projects.

Ernest Muller of Cornell University continued his investigation of the surficial geology of Chautauqua County assisted by Donald Noble.

Fieldwork supplemental to the State Geologic Map was carried on by paleontologists and stratigraphers during the 1956 field season. Irving H. Tesmer of Rutgers University extended Upper Devonian studies eastward from the Jamestown and Cherry Creek quadrangles. His report on 15-minute quadrangles in southwestern New York was received. Donald B. Potter of Hamilton College, assisted by Brian Davis,

continued stratigraphic and structural studies in the Hoosick 15-minute quadrangle. The complexity of the geology will necessitate much more fieldwork. A preliminary report and map was submitted. One month in the field enabled W. A. Oliver, Jr. of Brown University to complete stratigraphic studies of the Onondaga limestone in western New York.

Three grants were made to student geologists under the New York State Museum and Science Service Honorarium program:

1. Willard Leutze of Ohio State University, Stratigraphy of the Camillus group east of Syracuse.
2. Thomas Talmadge of New York University, Structural and stratigraphic studies in the deformed Cambrian and Ordovician rocks near Old Chatham.
3. Robert Shumaker of Cornell University, Pleistocene mapping near Scipio and Union Springs.

All returned summary reports before April 1, 1957.

1957—58

John H. Johnsen continued to study the Ordovician limestones west of the Adirondacks, assisted by Charles Rockwell of Harpur College, State University of New York. The fieldwork is limited to the limestones of Lewis County, and special field checks are being made for rock contacts needed for the State Geologic Map.

Ernest Muller, assisted by Charles Ruth, is continuing investigations of the glacial geology into Cattaraugus County, especially in the Allegheny River watershed, where particular attention is being paid to the area of the proposed Allegheny Reservoir to be flooded by the Kinzua Dam.

Irving H. Tesmer was employed for a period of one month to investigate the bedrock geology in the same area. His work was partially supported by a grant from the Geological Society of America.

Donald Potter, again assisted by Brian Davis, is mapping the Hoosick 15-minute quadrangle.

For several years past, we have planned a research program in the Upper Devonian rocks of central New York and in the Catskill Mountains of eastern New York. A long-term and difficult problem in stratigraphy, paleontology and sedimentation is foreseen which, for the first time, will provide information on the succession of these rocks which millennia ago were deposited in a great delta similar to the present Mississippi Delta. Robert G. Sutton of the University of Rochester, assisted by Frederick Manley, began the research which will afford basic scientific data and will also yield information for oil and gas companies.

With the advent of the St. Lawrence Seaway, a number of Lake Ontario ports will come into greater prominence. Port of Oswego will handle a much larger volume of lake traffic, especially with its rail connections to Syracuse and the Pennsylvania coalfields. Industrial construction in the Oswego area will increase. Much of this area is deeply buried by glacial deposits. We, therefore, proposed to explore these deposits for water supply, engineering foundations and sources of construction material. Russell F. Kaiser of Syracuse University used a technique of mapping which involves geological interpretations of soil maps, concentrating on the area around Oswego.

Three grants were made to student geologists on the Honorarium program.

1. Willard Leutze, Stratigraphy of the Camillus group in central New York.
2. Kenneth Kothe of Cornell University, Schunemunk 15-minute quadrangle.
3. Richard Berry of Yale University, Precambrian portion of the 15-minute Whitehall quadrangle.

Field Research of Permanent Employees

D. W. Fisher and L. V. Rickard spent some time making field checks for geologic contacts to be used in the State Geologic Map.

J. A. Graham spent a month in outcrop mapping of portions of the Peach Lake, Lake Carmel and Brewster 7½-minute sheets of the Carmel 15-minute quadrangle.

D. W. Fisher is completing fieldwork on the bedrock geology of the Plattsburgh and Rouses Point 15-minute quadrangles. He and Rickard have also made trips in connection with the State Geologic Map to the Taconic region of eastern New York, the St. Lawrence Valley and southwestern New York.

Laboratory Work and Compilation

In 1956, J. G. Broughton began writing a text dealing with the geologic history and applications of geology in New York State. There has been no such summary in a generation for advanced high school students, college undergraduates and interested laymen. In view of the primary importance of the mantle rock in New York State, a discussion of the soil and glacial deposits will precede the section on the geological history of the older rocks.

D. W. Fisher has carried on extensive library research and laboratory studies of *Tentaculitids, Hyolithids and other conical shells of unknown*

biologic affinities as his contribution toward the *Treatise on Invertebrate Paleontology*, an encyclopedia of some 28 volumes on all described genera of fossils to date. This involves reading articles in foreign journals and corresponding with paleontologists over the world. Fisher's study of the bedrock geology of the Canajoharie, Fonda and Amsterdam 15-minute quadrangles has been completed.

The majority of Rickard's time was directed toward the compilation of the Paleozoic portion of the New York Geologic Map. The latter part of 1956 was spent in a survey of existing knowledge and information and actual drafting was initiated in 1957 and is now about two-thirds complete. Some work has been done on manuscripts describing the stratigraphy of the Lower Devonian limestones in eastern and central New York and on the bedrock geology of the Richfield Springs quadrangles.

Four of the five maps showing the location and records of deep gas wells of New York State have been compiled by W. L. Kreidler, assisted by Bartz, Bowerman, Johns and former employees of the Wellsville office.

J. A. Graham, prior to his resignation, completed the editing and revision of a U. S. Geological Survey manuscript entitled "The Mineral Resources of New York State."

Office Activities and Administration; Conferences and Meetings

A large percentage of the State Geologist's time was devoted to carrying the necessary load of activities which resulted from the vacancies in two scientific positions. Extensive correspondence and interviewing of candidates in connection with possible appointment to vacant positions resulted in filling three of the four vacancies.

Two extensive memoranda were forwarded for the information of the Joint Legislative Committee on Interstate Cooperation: one dealing with the storage of petroleum products and wastes in underground rock formations of New York State, the other dealing with problems of production of oil and gas in the State, in general, and particularly in offshore waters.

At the request of the Governor's office and Commissioner Allen, Broughton and J. R. Dunn, the latter of Rensselaer Polytechnic Institute, went to Niagara Falls to inspect the damage caused by the disastrous rock fall at the Niagara Mohawk Power Corporation plant and to consult with State, municipal and private officials. Later in the summer, Broughton, Fisher and Graham spent three days inspecting the Niagara cliff line from the falls to Lewiston. One serious danger

point and several lesser ones were noted and called to the attention of the Niagara Frontier State Park Commission. As a result of this warning, precautionary measures were taken.

Broughton and associates carried on the checking and correlation of individual mineral production statistics for the calendar year 1956. He also reviewed and edited the geological portion of manuscripts dealing with various drainage basins for the State Health Department; advised the Bureau of Environmental Sanitation with respect to underground disposal of chemical wastes from the Niagara Falls area; cooperated with the State Health Department in a study of congenital malformations which may have some correlation with areas in the State of slightly greater natural radioactivity than usual; advised the city of Batavia with respect to the effect on water supply of the establishment of a new railroad grade through the city.

Kreidler advised the Conservation Department on leasing of reforestation lands. He also supplied data to the Public Service Commission. The staff cooperated with representatives of the oil and gas industry in the planning and preparation for the annual New York State Geological Association meeting held at Wellsville.

Data were supplied to the New York State Conservation Department in connection with the water supply for their installation at Perch Lake in Jefferson County.

Broughton assisted in revising plans for laboratories of the State Science Service and of the Geological Survey in particular, in the proposed ninth floor of the Education Department Annex.

The Survey compiled and issued its 8th Annual News Letter.

Because the Geological Survey does not carry on any regulatory activities, Broughton resigned as a member of the Regulatory Practices Committee of the Interstate Oil Compact Commission. As chairman of the Mineral Resources Committee of the Interstate Commission on the Lake Champlain Basin, Broughton prepared a summary report for the annual meeting and delivered it for the committee.

The following conferences and conventions were attended by staff members for professional purposes:

Broughton

20th International Geological Congress, Mexico City

Second Nuclear Engineering and Scientific Congress, Philadelphia, Pa.

Northeastern Mining Branch Conference of American Institute of Mining Engineers, Hershey, Pa.

Joint Legislative Committee on Interstate Cooperation Conference on Flood Waters and Disaster
New York-Vermont Interstate Commission on the Lake Champlain Basin, Basin Harbor, Vt.
New York State Geological Association, Wellsville, (entire staff)
Friends of the Pleistocene, Massena

Fisher and Rickard

Spring and fall meetings of the Paleontological Research Institution
American Field Conference of Pennsylvania Geologists, Trenton, N. J.

Kreidler

American Petroleum Institute meeting, Pittsburgh, Pa.

Servos

American Association for the Advancement of Science, New York City

Miscellaneous Service Activities of the Staff

All staff members, but especially Broughton and Fisher, made frequent trips to oversee the work of temporary geologists and students. Broughton made an investigation of purported tungsten occurrences in Rensselaer County and had chemical analyses made to support the work. He also made an extensive investigation of the relation of anorthosite to industrial sites in the Adirondacks for the Reynolds Metal Company at the request of the New York State Department of Commerce.

All staff members consulted with uranium prospectors and made laboratory investigations and field visits to the reported occurrences.

Broughton prepared an opinion for the Governor's office concerning the effect of industrial construction in Saratoga Springs near the site of one of the State wells.

Interest in deep drilling for gas in the Allegany State Park was increasing. A number of oil company geologists have spent extensive time in the office studying our well records and file of well cuttings.

Professional Activities

Broughton: Public Relations Committee of the American Geological Institution; a representative, Association of American State Geologists on Program Committee for the Second Nuclear Congress; secretary-treasurer, Industrial Minerals Division, A.I.M.E., and chairman of the By-Laws Committee.

Broughton attended the annual meeting of the Board of Visitors of the Geology Department of Union College.

The Museum

Curatorial Activities

The care and preservation of collections, service to the inquiring public, assistance to the scientists, accessions and loans constitute the important duties of curators in a public natural history museum.

Archeology

The Curator of Archeology answered inquiries from 102 visitors to his office, predominantly requests for the identification of Indian artifacts or other anthropological data. Among these items were skele-

The skull of an aboriginal inhabitant of New York State in process of cleaning by the Curator of Archeology, prior to study and storage in the collections

tons excavated near Sprakers for Edward J. Sheehan of Fonda and advice on Iroquoian material culture to Thomas H. Benton for a mural in the St. Lawrence Seaway Office. The Curator opened the masks collection to Encyclopaedia Britannica Films. Other inquiries were answered by mail.

A substantial portion of the Curator's time was devoted to assisting the State Archeologist in research. These time-consuming duties which are properly those of a scientific aide included the systematic sorting

of artifacts by reference to the catalog and their inventory; the identification of certain pieces illustrated on plates, and the identification of stones, shells and bones. Maps of two sites were drafted and a map of the Hudson Valley was keyed with site locations.

Routine duties of caring for the collections occupied the greater share of the Curator's time. The State Archeologist requested that a much more detailed type catalog should be maintained with each significant specimen receiving its own identification number. Collections are being checked and an item catalog made by types with each significant piece receiving a serial subnumber. Work has been completed for the collections from Albany, Allegany, Broome and Cayuga Counties and is presently concerned with Chemung County.

Ethnological specimens which require protection against insects—primarily the Iroquois masks and the clothing—have been filed in four new cabinets. Boxing the archeological collections in dust-tight containers with identifying labels has proceeded.

A number of collections came to the State Museum. The more important of these accessions included:

Heath Collection, Beloit, Wis. (selected items purchased)

Museum, State University Teachers College at Potsdam (donated)

Percy W. Dake, Saratoga Springs (pottery sherds)

Miss Maude M. Hinckel, Mechanicville (wooden ladle)

James A. Magee, Lake George (two chipped stone artifacts)

Roy Latham, Orient (charcoal samples)

St. Lawrence University (stone artifacts)

Rubin Frodin, Albany (pair of leggings)

Chauncey P. Williams Collection

Edward Brooks Collection

Archibald T. Shorey, Albany (three masks and a pipe fragment)

Francis C. Kellogg, Santa Barbara, Calif. (bow and two arrows)

H. V. Shiefer, Cleveland (flint samples from the Flint Ridge)

Regent Roger W. Straus (string of Egyptian glass beads)

Foster Dysinger, Roberson Memorial Museum, Binghamton, (pottery sherds)

Staff activities produced collections from sites excavated at Stony Brook, Sugar Loaf Hill and Wading River on Long Island; the Dake site on Fish Creek in Saratoga County; the Morrow site on Honeoye Lake, and numerous articles from site surveys. These were accessioned,

cleaned, repaired and cataloged. During the year 205 slides were cataloged and added to the collections.

Ten loans of anthropological articles were made. Two loans were returned.

An open exchange was arranged with the United States National Museum. A series of representative Point Peninsula pottery sherds was donated to the Roberson Memorial Museum.

The New York State Museum exhibited at the University Museum of the University of Pennsylvania during the International Congress of Anthropological and Ethnological Sciences at Philadelphia, and contributed to the special exhibit of Hopewell Art and Archeology of the Wisconsin State Historical Society during the annual meeting of the Society for American Archaeology.

Botany

The backlog of routine preparation of specimens of all nonvascular plants was 75 percent completed. All of the nonvascular plants were sorted and about 1,000 specimens were prepared for the permanent and exchange collection. About 50 percent of the collection of Agaricaceae was pest-proofed. The curator was aided from December 6 to December 31, 1956, by Mrs. Clara Schultz as an herbarium assistant.

Entomology

The transfer of insect specimens from the obsolete cardboard boxes to the National Museum type drawers was continued. Transfer of the Hymenoptera and Hemiptera was completed, and about half of the Coleoptera, totaling some 90,000 specimens.

Zoology

Specimens from the mammal survey were tagged, numbered, cataloged and added to the general collections. (See also report on the Mammal Survey.)

Accessions etc.

Botany

The herbarium was enlarged by the collection of some 3,496 specimens, including 891 fungi, 1 alga, 1,106 mosses and liverworts and 1,498 vascular plants. Most of these plants were collected by the Curator. All but nine of these specimens were collected in New York State.

Under exchange arrangements, our collection received 16 specimens from the University of California and 35 specimens from the United

States National Herbarium in Washington. Gifts of the specimens were made by 10 individuals. Including these gifts and exchanges, the total accessions numbered 4,961 specimens.

Entomology

Eight silkworm life cycle exhibit cases were given to the Museum by the New York Office of the Central Raw Silk Association of Japan. These will be used to loan to schools and smaller museums. Several thousand insect specimens were collected by the Curator on special collecting trips and by the personnel of the field projects.

Zoology

Accessions from the small mammal survey included about 333 skins with skulls, and 73 whole skeletons, as of March 31. There were also 50 skulls without skins. A number of additions were made after the headquarters were changed, but these have not yet been cataloged. A collection of birds' eggs was donated by Mr. John Belknap of Gouverneur.

State Lists

The Curator of Botany was especially active in adding new records to county lists, with 773 new records of species and subspecies in 35 counties.

Two taxa of vascular plants were added to the State list. For the Checklist of Mosses, 38 additions to the records for different quadrangles were made.

One new blackfly record was made, and it is probable that the collection of sandflies will also contain new records.

In the mammal survey, weights, measurements and reproductions data were recorded for 1,412 specimens of mammals.

Loans

Loans of biological material to responsible institutions and individuals were made as follows:

Plants: 5 loans of types of fungi and related specimens; 1 to the New York State College of Agriculture at Cornell University, 1 to the University of Iowa, 1 to the University of Michigan and 2 to the University of Tennessee, in all, comprising 34 specimens.

Insects: 95 Meloid beetles and 64 Tineid and Blastobasid moths to Dr. Richard Selander, Illinois Natural History Survey, for research studies.

Nineteen *Calliopsis* bees to Dr. Charles Michener, University of Kansas, for research studies.

Three drawers of Forest Pest exhibit material to the Conservation Department for a foresters' meeting.

One silkworm life cycle exhibit case to the Rensselaer Junior Museum, Troy.

Five insect exhibit cases for exhibition in schools in the East Greenbush Central School District.

Donations

Paratypes of the blackfly *Cnephia loisae* Jamnback were sent to Dr. Alan Stone as a donation to the collections of the United States National Museum, Washington, D. C.

Geology

In addition to accessioning some recently acquired specimens into the mineralogical collection, the Curator made an effort to acquire new specimens. Collections of specimens, some of them fine suites that are eminently suitable for display purposes, were acquired from:

Mr. Elmer B. Rowley, Glens Falls
Dr. A. C. Worth, Jr., Albany
Mr. Jerome F. Lapham, Glens Falls
Mr. Robert A. Zullo, Albany
The Anaconda Company, Grants, N. Mex.
Idarado Mining Company, Ouray, Colo.
New Jersey Zinc Company, Gilman, Colo.
Wyoming Uranium Corporation, Lander, Wyo.
Commercialores, Inc., Clover, S. C.
Talache Mines, Inc., Boise, Idaho
Prof. C. O. Hutton, Stanford, Calif.
Howe Sound Company, Holden, Wash.
Calumet & Hecla, Inc., Calumet, Mich.
Minerva Oil Company, Cave-in-Rock, Ill.
Bell Minerals Company, West Paris, Maine
The Anaconda Company, Butte, Mont.
Kaiser Aluminum Corporation, Fallon, Nev.
Kennecott Copper Corporation, Salt Lake City, Utah
New Park Mining Company, Keetley, Utah
Russel R. Schaefer, Crooked Creek, Alaska
Pickands Mather Company, Duluth, Minn.

In addition, a large collection of specimens donated by Mr. E. E. Davis, Norwich, in 1932, was unpacked and curated. The Curator collected specimens which were accessioned into the general collections from Tilly Foster Iron Mine and from the Shawangunk Zinc Mine.

In December 1956, the Capital District Mineral Club was founded with an initial membership of some 40 people which has now increased to more than 70. This club was sponsored by the New York State Museum and has an active program.

More than 50 mineral sets for classroom use, and individual minerals, were sent out.

After extensive correspondence with curators in other museums the Curator devised and executed a system for cataloging the specimens in the State Museum.

The Curator carried out several X-ray diffraction examinations on minerals for the State Museum in the laboratories of Yale University, and six radioassays were carried out on radioactive samples.

More than 30 collections of rocks and individual specimens were sent to the Museum for identification. The determinations varied in difficulty from megascopic sight identification to detailed X-ray diffraction and microscopic determinations.

The Curator assisted other scientists on the staff by identifying mineral and rock specimens.

Specimens of calcite from Sterlingbush were donated to the Geochronometric Laboratory, Yale University, for use as a standard in radiocarbon date determinations.

Service Activities

Service activities of the curators in connection with the Geological Survey include the following:

Paleontology. Assistance was rendered to a number of visiting scientists. William B. N. Berry of Harvard College visited the Museum for four days and was assisted in his study of graptolites. Professor Harlan Banks of Cornell University worked over fossil plant study material greatly reducing it. Erwin Stumm of the University of Michigan was assisted for several days in his study of fossil corals. In addition, data on fossil types and fossil localities were supplied to a number of other cooperating scientists and laymen.

Type numbers were changed from fractional number system to serial number system on 525 exhibit specimens. Fifty-three specimens were treated to stop or prevent disintegration. The contents (1,955 type specimens and 2,972 exhibit specimens) were removed from 51 Museum

exhibit cases and the subgallery of fossil plants and most of the material was cataloged and stored. Collections containing 3,598 specimens were packed for shipment. Seventy-nine accession entries were made in the locality and accession records. One thousand four hundred and fifty-three specimens were ticketed with locality numbers. As usual, a considerable amount of time was spent in keeping type catalog card data up to date.

Important *Accessions* turned over to the Museum by scientists:

Paleontology:

a. One hundred and five fossil specimens from various formations and localities in Chautauqua County, New York by Mr. Irving H. Tesmer of Dunkirk.

b. Forty-seven fossil specimens from the Syracuse, New York area by Mr. Willard P. Leutze, Ohio State University, Columbus, Ohio.

c. A collection of 1,051 specimens from the Hoosick Falls area, New York–Vermont by Mr. Lawrence D. Bonham, University of Chicago, Chicago, Ill.

d. Twenty mounted specimens of scolecodonts from the Devonian of Michigan were acquired in an exchange with Dr. E. R. Eller of the Carnegie Museum, Pittsburgh, Pa.

e. Two hundred and forty fossil ostracods (including 228 type specimens) by Mr. Lewis E. Stover, University of Rochester, Rochester.

Loans and Donations

Paleontology records eight loans. Among them The Arnold Collection of fossil echinii (approximately 3,494 specimens) from the Island of Jamaica was sent to the Paleontological Research Institution, Ithaca, on an indefinite loan.

The Curator's report records eight donations for teaching purposes to educators as far away as Truk, Caroline Islands and as near as Troy.

Professional Activities

Archeology

The Curator of Archeology carried on the correspondence and other duties of his position as secretary of the New York State Archeological Association. He attended the annual meetings of the Eastern States Archeological Federation and of several neighboring and local archeological societies.

Exhibits and Preparation Staff

The Assistant Commissioner, Assistant Director, Exhibits Planner, Exhibits Designer and both Preparators attended the Northeast Conference of the American Association of Museums held at Corning.

Museum Exhibits

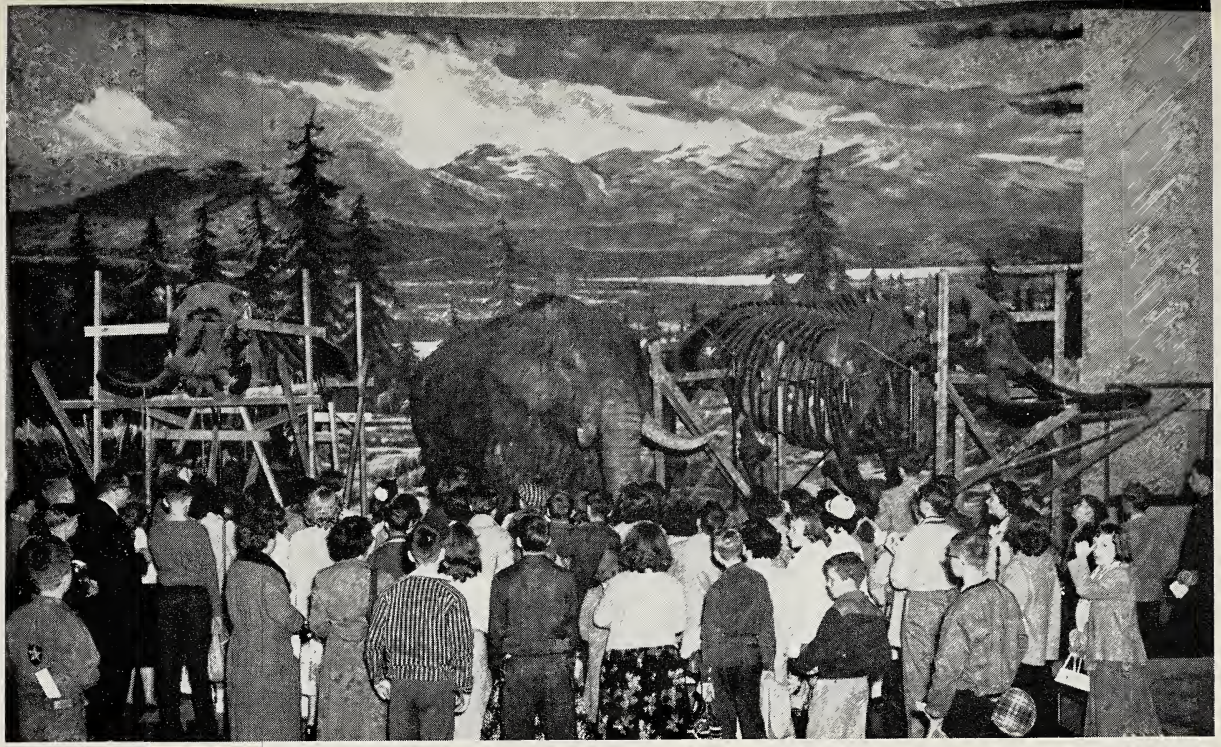
THE TASK OF RENOVATING AND modernizing the extensive series of exhibits got under way. Considerable time was expended, particularly by the State Geologist, the State Paleontologist and the Curator of Archeology, in making plans for floor layouts and distribution of exhibit subjects. The Assistant Director concentrated on more detailed plans for exhibits on mastodons and mammoths and for an earth-structure display in Orientation Hall. The Curator of Botany devoted many hours to laying out and supervising the painting of vegetation types on the large relief map of the State. He was assisted in outlining the types by Ralph H. Smith, ecologist, whose services were generously loaned for the purpose by the State Department of Conservation.

Seven alcoves, each containing a large exhibit case, were constructed in Orientation Hall, and a color scheme was drawn up for the floor. The hall was lighted from the ceiling by adapting the conventional type of "stove-pipe" fixture so that lamps can be changed from above without disturbing the fixed light-beam. The hall is clean, colorful, attractive and spacious, but as yet the display cases contain only temporary exhibits. Eventually, this hall will give a summary of the entire Museum and will serve as a focal center for school classes and other visitors.

The renovation of the large relief map of New York State was one of the major projects brought to completion during the past year. Begun in February 1956, the work of repair, restoration, correction of detail and the entire recoloring and relettering of the map was completed on November 5, 1956. Since that date, it has been necessary to repair damages incurred during the installation of the new railing, and in April an extensive restoration and repair job was needed when a small child ran across the map and caved in a large part of Lake Erie. In May 1957, with the help of two of the maintenance staff, the entire map was cleaned, washed and once more put into presentable condition.

Work on the Beaver Group in Biology Hall progressed slowly due to the fact that the same few preparators must work on a variety of other projects at the same time. During the period covered by this report the canvas for the background painting was hung and primed in readiness for the artist, Matthew Kalmenoff, who arrived in Albany on August 6 and spent the following 15 days painting the background scene. The

A group of foreign-exchange students gather at the completed relief map in Orientation Hall for an introductory lecture before touring the other exhibits.



By April 1957, the background of the large mastodon exhibit had been painted and work on the foreground was beginning. A group of school children look at the Ice Age scene and the mastodon skeletons which were still in their supporting braces. (The latter were erected as precautions against damage in the move from the former Hall of Vertebrate Paleontology, now Orientation Hall.)

foreground structure was built and nearly all of the accessory material was made and assembled. Specimens of muskrat, short-tailed weasel, white-footed mouse, red-back mouse, wood turtle and painted turtle were prepared for this group, and foundations for modeling the two beavers were made.

Two specimens for a proposed Wolf Group were received in the flesh as donations from the Ontario Department of Lands and Forests. These specimens, a young female and a pup which arrived in January and August, respectively, brought our total of animals for this group up to four. Except for preparation of the animals for future mounting, no immediate progress on this project is possible for some time to come.

A considerable amount of time was devoted to building a new Mastodon Group in the Hall of Paleontology. Canvas was hung on the 20 feet by 40 feet curved background. The canvas was primed and marked off in 12-inch squares for the artist, Edwin Becker of Delmar, and a temporary base structure was built and covered with burlap. The mural, which depicts the southeastern Catskills and foothills in the late Pleistocene, was completed during the year. Tracks of animals contemporary with the mastodon were modeled and dies were cast from them with which to impress them in the foreground of the group. The tracks include caribou, giant beaver, black bear, wolf, peccary and whooping crane. A number of glacial boulders were also modeled and colored for this group. The foreground was under construction at the end of the year.

Plaster casts of new scale models of mastodon and mammoth made by Dr. James L. Clark were received and assembled for the two exhibit cases adjacent to the mastodon group. Molds were made of these models and three copies made of each. Two were colored as they may have appeared in life, two were finished in a dark color and the last pair was given an ivory finish. The natural colored models were incorporated into "habitat" bases for exhibit and the remaining four copies were packed and stored. Another pair of casts were made and turned into a pair of relief models on bronze-finished wall plaques for the Education Section office. Preliminary studies and permanent background paintings were made for both mastodon and mammoth miniature groups.

Three underwater scenes based on two Devonian and one Silurian existing groups were designed and modeled in miniature. Scale models of various sponges etc. were then made and colored to work out new arrangements for the renovation of these groups. Several wax models were removed from these groups and packed for shipment to the studio of Chris E. Olsen for reference in painting new background scenes

which were completed. The new groups will be constructed during the 1957-58 year, using additional animals modeled by Mr. Edward Buehler of the University of Buffalo. Temporarily, the old underwater groups were placed at openings in the wall of a storage room in Paleontology Hall and lighted from above. A new exhibit of trilobites and eurypterids was built and installed near the entrance of Paleontology Hall to replace the many specimens of these animals which were removed from public view.

Plans for moving ethnological exhibits installed in the east mezzanine in the year 1955-56 to Myron H. Clark Hall are in process as are a number of exhibits which will complete the series. Thus, in one hall the life of the Iroquois People will be illustrated as a unit. Also in process are plans for a synoptic exhibit of the archeological history of New York. Based on cultural levels, these exhibits will be oriented toward the function of the artifacts that the archeologist recovers in his excavations. A series illustrating the processes of interpretation is also being planned. The Curator of Archeology is presently engaged in planning floor layouts, dismantling older exhibits in Morgan Hall, checking the articles which will be needed for new exhibits and in research of the literature covering these phases of Indian life and history.

A special exhibit honoring the "Four Kings of Canada" was planned and installed and proved very popular. The Curator of Archeology assumed responsibility for the safekeeping of the ethnological items borrowed from the Six Nations Council, Ontario, Canada; St. Peter's Church, Albany; the Ashmolean Museum, Oxford, England; the Musée de L'Homme of Paris; the New-York Historical Society; the Museum of the American Indian, Heye Foundation, the Albany Institute of History and Art and the Mohawk-Caughnawaga Museum of Fonda. When the State Historian's office came into possession of a tomahawk attributed to Joseph Brant, the Curator of Archeology planned and installed a special exhibit of the life and time of the celebrated chief centering upon the tomahawk. A complete photographic record was made of both exhibits.

In connection with the return of the articles borrowed for the Four Kings exhibit, new exhibits were investigated and ethnological materials inspected in the Heye Foundation and the American Museum of Natural History. Many ideas were observed which will be of use in our program.

A large number of "minor" projects were planned and/or executed for the exhibit halls. These projects ranged from a more presentable temporary barrier for "sidewalk superintendents" to iron-and-wood railing for permanent installation in front of exhibits. Numerous dis-

plays in Geology, Paleontology and Biology Halls were made more attractive by the use of paint and new labels. Considerable material was retired to storage in the first two halls, making them appear more spacious and inviting. It was necessary to build storage-workrooms in these two halls in order to simplify the task of the curators and give the specimens safe repository.

Among the many smaller jobs which received attention were the following:

The Van Rensselaer cannon in the Hall of History was overhauled and repaired, all four wheels and tires being badly in need of attention. Exhibits used by various sections of the Museum for the 1954 Convocation were repaired and renovated. New compositions were worked out to make them fit the cases in Orientation Hall where they were installed. The sponge models in Paleontology Hall were repaired as was the restoration of the Gilboa tree and the fossil slab of the Gilboa tree.

Seventeen frogs and 12 turtles of various species were received from the Conservation Department at the close of the State Fair. Molds and casts were made of these specimens for use in new habitat groups as well as for duplicate exhibit material wherever needed. A ruffed grouse was also mounted.

A considerable number of color photographs (35mm. transparencies) were made during the year for use in an automatic slide projector to be installed in Orientation Hall. The series of pictures, when complete, will be arranged in story-telling sequences on plants, animals, conservation problems etc. in New York State.

Twelve special and temporary exhibits were set up and displayed during the year, as follows:

Original illustrations by Clayton Seagers, New York State Conservation Department

"The Four Kings of Canada." Paintings, silver, wampum, Indian artifacts etc.

Undersea paintings by Chris E. Olsen

"National Art Contest for the Handicapped." Paintings

"This Is the American Earth." Mostly photographs

Photographs of "Wild Animals and Scenery of Alaska," by W. Scotti Steenberg, McKinley National Park, Alaska

Photographs of National Parks and Monuments by Philip Hyde, Greenville, Calif.

Watercolor paintings by members of the State Museum Sketch Group

Animal drawings by Flora Burgess Parker, Bennington, Vt.

"Indian New Year." Photographs by W. N. Fenton

Photographs by staff members of the Cranbrook Institute of Science, Bloomfield Hills, Mich.

Photographs by Tan Seng Huat, Malaya

Loans of exhibits were made to other museums as follows:

"How To Photograph Wild Animals." A series of photographs by W. J. Schoonmaker. Loaned to the State University Teachers College at New Paltz, and to the Rochester Museum of Arts and Sciences.

"How Illustrations Are Made and Reproduced." Original illustrations and reproductions from them by W. J. Schoonmaker. Loaned to the State University Teachers College at New Paltz, and to the Berkshire Museum, Pittsfield, Mass.

"Museums Look Ahead." Photographs. Loaned to the Nebraska State Historical Society; Idaho Historical Society and to the Rochester Museum of Arts and Sciences.

"Wild Animals and Scenery of Alaska." Photographs by W. Scotti Steenberg, McKinley National Park, Alaska. Loaned to the Berkshire Museum, Pittsfield, Mass.

Cooperative Work

The Preparation Section furnished information and advice on museum techniques and material to workers from the Conservation Department Wildlife Laboratory; the State University College for Teachers at Albany; staff members of the Kalamazoo, Mich., museum and representatives of the Rensselaer County Historical Association as well as the Rensselaer County Junior Museum.

The Curator of Entomology conducted field classes in insect study for the fifth and sixth grades of East Greenbush schools. The field trips were partly experimental in that methods of handling groups of youngsters on an "insect hunt" were explored.

He also taught taxonomy of the beetles during a laboratory-lecture period for the biology class at the State University College for Teachers at Albany.

The Public

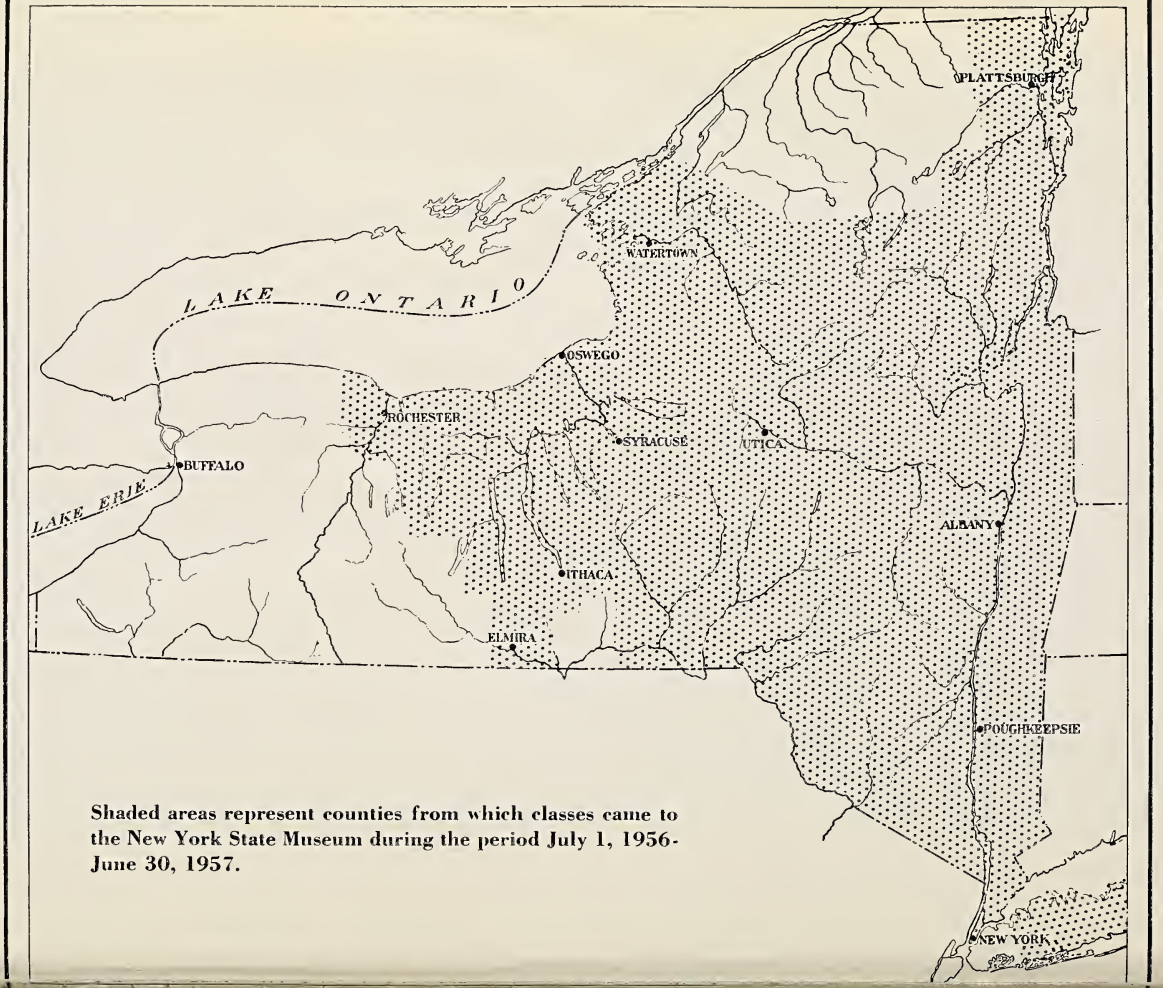
For the first time in a number of years, a systematic check was obtained on attendance to the exhibit halls. Total counts were made by the guard staff on successive days of succeeding weeks; i. e. Monday of the first week, Tuesday of the second week etc. Visitors were tallied, therefore, on 51 days during the year, or 15½ percent of the days that the halls were open during the year. The annual attendance, based on

A visiting school group, with their teacher and the Museum's Education Supervisor, watch an exhibits preparator redecorate the State relief map in Orientation Hall. The map was converted from geological formations to principal vegetation types of New York State.

this sampling, was 111,560 persons. Although the sampling was restricted due to lack of manpower, we believe that it was a fair index to total attendance. As a result, the attendance figure for 1956-57 is lower than for several years preceding when general estimates were based on a few random (and generally high) counts.

Attendance on individual days, as revealed by the sampling, varied greatly, from a low of 125 to a high of 829 persons. This does not include the two-day Washington Birthday week-end when the Museum had a total of 1,920 visitors.

In addition to their usual routine duties of protection of the exhibits and visitors, answering inquiries and distributing or selling publications, the guard staff performed a great variety of other tasks. Among these were: assisted the curators, exhibits staff and maintenance men to install and remove exhibits and move cases; repainted background of exhibits and worn areas on floors; acted as drivers for museum vehicles, and assisted in many ways not connected with their assigned duties to make the Museum of greatest service to the public.



Shaded areas represent counties from which classes came to the New York State Museum during the period July 1, 1956-June 30, 1957.

Special Services

Program for Educational Groups

ATTENDANCE OF PERSONS IN ORGANIZED educational groups to the Museum increased from 27,989 in 1955-56 to 28,277 in 1956-57 (a 1 percent increase). A much more substantial gain was recorded in the number of guided tours which rose by 13 percent and in the tour attendance which increased by 9 percent. The table below shows group attendance and educational service for the past five years:

	1952-53	1953-54	1954-55	1955-56	1956-57
Number of groups	685	745	753	809	798
Total group attendance	21,778	22,933	23,955	27,989	28,277
Number of tours	485	540	569	577	650
Tour attendance	10,170	10,664	11,644	12,960	14,106
Introductory talk attendance	1,188	1,604	1,502	752	49

In the guided tour program this year, emphasis was continued on a museum lesson which correlates museum exhibits with the school curriculum and which meets the specific needs of each class. The content of the tour is selected by the teacher after consulting with the Education Supervisor. A tour is designed to obtain the best learning situation possible. Most classes are assigned two instructors in order that each child may be able to see the exhibits clearly. Questions and discussion between students and instructor are encouraged. When time allows, classes are given the opportunity to handle and examine selected Museum specimens.

Whenever possible, a full guided tour was provided as a substitute for the 10-minute introductory talk. It has been found that a guided tour more adequately meets the needs of most groups.

The Scientists, Curators and Exhibits staff took part in the tour program when highly technical instruction was requested. Guides and number of guided tours are listed below:

GUIDES	NUMBER OF TOURS	NUMBER OF INTRODUCTORY TALKS
Rubin	304	1
Jones	277	1
Alberts	37	—
Servos	8	—
Fenton	6	1
Reilly	6	—
Gillette	4	—

GUIDES	NUMBER OF TOURS	NUMBER OF INTRODUCTORY TALKS
Cahalane	2	1
Smith	2	—
Broughton	1	—
Fisher	1	—
Koster	1	—
Schoonmaker	1	—
	650	4

Of the 28,277 attendance of educational groups, 23,761 (84 percent) were from school classes and 4,516 (16 percent) from Scout groups, clubs, camps and other nonschool organizations. The following tables indicate the distribution by grades and services:

Nonschool Group Analysis

	NUMBER OF GROUPS	TOTAL ATTENDANCE	TOURS		INTRODUCTORY TALKS	
			NUMBER	ATTENDANCE	NUMBER	ATTENDANCE
Youth	153	3,316	28	481	4	49
Adult	23	1,200	17	464	—	—
	176	4,516	45	945	4	49

School Group Analysis

GRADES	TOTAL ATTENDANCE	TOURS		INTRODUCTORY TALKS	
		NUMBER	ATTENDANCE	NUMBER	ATTENDANCE
K, 1-3	3,219	110	2,381	—	—
4-6	8,800	290	6,138	—	—
7-9	9,645	159	4,137	—	—
10-12	1,155	12	250	—	—
Multigraded	45*	23	23**	—	—
Unclassified	31	1	16	—	—
College	866	10	216	—	—
Adult Educ.	—	—	—	—	—
	23,761	605	13,161	—	—

*Teachers only; balance of attendance included in proper grade divisions. Multigraded refers to groups composed of a mixture of grades not fitting into one of the categories listed above.

**Teachers only; balance of attendance has been apportioned to proper grade divisions.

The Museum attracted school groups from 46 counties of New York State. Educational groups also came from: California, Connecticut, Massachusetts, New Jersey and Vermont. The shaded areas on the accompanying map show the county distribution of classes.

Related Activities

Guided tours were only one phase of the Education program. A great deal of time was spent counseling with teachers, scheduling tours, answering letters, studying source material, conferring with staff members in the preparation of museum lessons and reading popular scientific publications so that we could recommend the best of these to interested visitors.

Mrs. Rubin was a member of the Education Department's Parking Committee. The committee was set up to recommend solutions to the employee and visitor parking problem. Mrs. Rubin prepared for the committee an estimate of the number of school buses visiting the Museum during the year.

From January through April, Mrs. Rubin and Mrs. Jones attended a weekly seminar session on the American Indian. The meetings were led by Dr. Fenton and were also attended by Mr. Gillette and Mr. Smith.

A new descriptive folder, *Here's Your State Museum,* was prepared. The old folder was almost completely revamped; new photographs, text and floor plan were used.

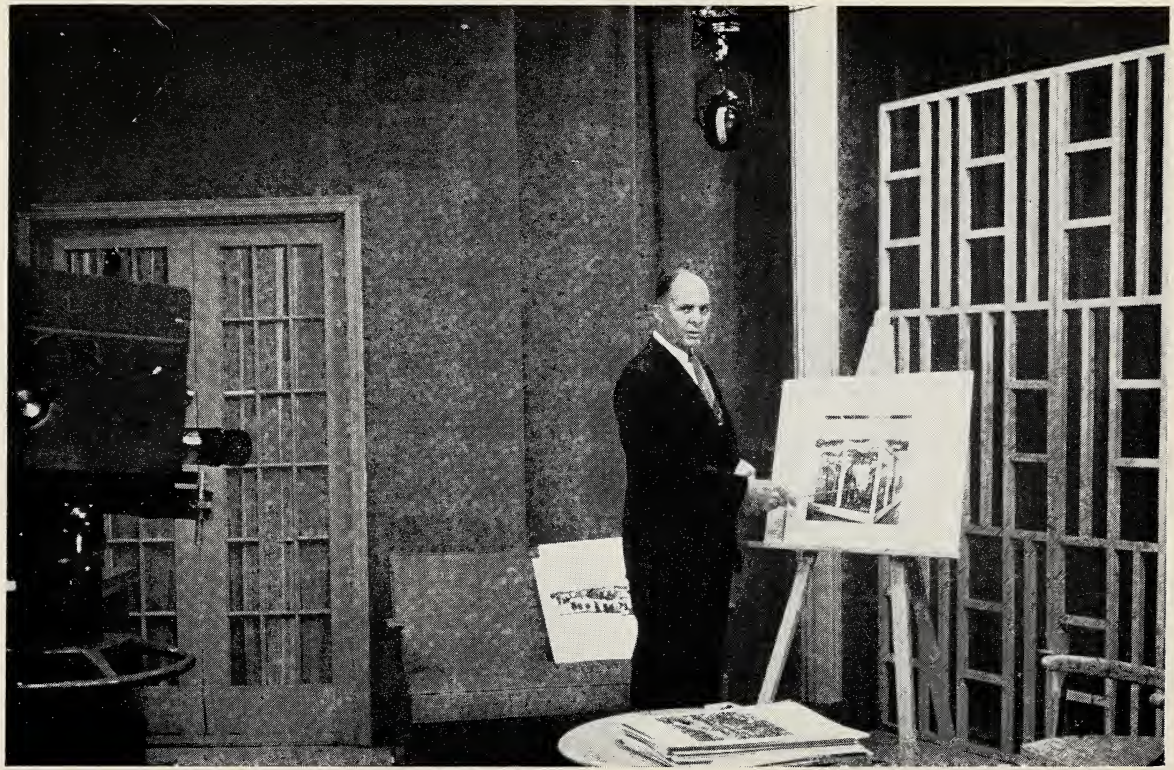
Problems

The problems encountered by the Education Section are many.

Group attendance to the Museum rises sharply in the fall and spring. The breakdown from July 1956 to June 1957 follows:

	TOTAL GROUP ATTENDANCE	GROUP TOUR ATTENDANCE
July	462	84
August	269	51
September	503	151
October	2,790	2,031
November	2,827	1,775
December	1,055	704
January	868	675
February	1,863	1,035
March	3,684	1,520
April	2,476	1,312
May	7,671	2,754
June	3,809	2,014

Because of this seasonal attendance, it was found that each instructor often gives five or six tours a day during October, November, May and June. Teachers have been asked to try to schedule their visits for other months, but weather and bus schedules are important factors in this peak attendance.



A television program on modern exhibit preparation and construction is given in Station WRGB by the Assistant Director, State Museum. The demonstration was one of a series of lectures which were contributed by staff members of the State Museum and Science Service to the program of the Mohawk-Hudson Council on Educational Television.

The lack of adequate parking space for school buses is an important problem and results in classes arriving late and conflicting with other scheduled classes.

Within the Museum, more good exhibits constitute the greatest need. The Indian groups, new animal habitat groups and the mastodon exhibit are popular and effective for use with educational groups. Most of the other exhibits require enlargement and improved lighting. The ventilation and acoustics also require modernizing in the Museum halls to make improved teaching possible. The Museum is proceeding slowly to effect such modernizations.

With the increase in tours and with three people on the Education staff, the need for a separate classroom was felt much more strongly this year.

Public Lectures

Two special lectures on the Indian History of New York State were given by the Curator of Archeology to the Teachers Workshop of the Sixth Supervisory District at the Guilderland Central School; a similar talk was given to an adult group at the Third Reformed Church in Albany. In October, the Curator appeared on WRGB's TV Schooltime at the request of Mrs. Nina T. Flierl and answered the request of Mr. Theodore Cassevant to speak to his Vocational Guidance Class at Philip Livingston Junior High School.

The Curator of Geology delivered talks on the geology and mineral resources of the State to school groups in the Ellenville High School and Philip Livingston Junior High School. He was invited to speak before the New Haven Mineral Club.

A trip was made by the Curator of Zoology to White Plains for a talk to the members of the White Plains Garden Club on birds of the State. Local trips were made, both during days and evenings to give talks on birds and animals to various schools and clubs of the region. A total of 14 such talks was given, the average audience size being about 50 people. Two sessions were taught at the Conservation Workshop, Alps, N. Y., during September. About 50 students attended each session. A talk on biological sciences was given during "Career Day" at Chatham Central School.

A public lecture entitled "Wild Animal Photography," illustrated with slides, was delivered by the Exhibits Planner to the Albany Camera Club.

The Senior Museum Technician gave a talk on the reproduction of accessory materials and on models of amphibians to a science group in Brubacher Hall at State University College for Teachers at Albany. A

group of 18 students from the Albany Academy for Girls visited the Preparation Laboratory for a talk on museum techniques.

Museum Library

The position of museum librarian was vacant from August to December 1956. In consequence, considerable disorganization resulted from the lack of library service for nearly five months.

The task was to create some degree of order. This entailed a great amount of sorting, cataloging and filing. Many publications were fitted into gaps in the library accessions. Reprints and pamphlets of value to the staff were added to the file. Duplicate materials were taken to the New York State Library, Gift and Exchange Section. The former Assistant Director's personal files were stored in the State Library stacks where he was allotted space. Other material has been sorted by subject matter and will eventually be examined for choice by the professional staff.

Two charts, plus a key to the charts by James Hall, former State Geologist (1836-1882), were found standing between the stacks. Since these charts are valuable, a specially constructed case was made for them.

A routing procedure to the staff of periodicals received by the Museum Library was instituted. A list of publications received was circulated to the staff and they indicated those which they desired to be sent to their offices. Weekly these periodicals are sent out from the Museum Library.

With the Assistant Commissioner's bibliography on the American Indian, work was begun on the preparation of a checklist of the material found in the State Library. The original list was brought up to date by the addition of new publications. Considerable time was spent in recording the call numbers of such books as are in the State Library. The information has been assembled and will be published in the Educational Leaflet Series under the title: "Selected Reading List of Books and Articles on the Indians of North America in the New York State Library."

A great deal of the Librarian's time has been spent in searching for reference material requested by the staff and in checking the State Library holdings of books and periodicals which are useful to them. This is a particularly valuable service to those engaged in research of any kind.

Two new reference books were acquired by the Museum Library. Through the New York State Library we were able to exchange our

old edition (1878-89) of the *Encyclopaedia Britannica* for a later edition (1942). We received *American Men of Science, The Biological Sciences,* 9th edition, volume 2.

An Honorarium report was received and added to our file. This report is "Till Texture Variation and Pleistocene Deposits of the Union Springs and Scipio Quadrangles, Cayuga County, New York," by Robert Clark Shumaker.

Photography

A TOTAL OF 128 APPROVED requisitions were processed during the year. This work resulted in the following:

412	**black and white photos taken directly**
1,024	**negatives processed from field photographs by other members of the staff**
	A total of 3,173 prints and enlargements made from the negatives mentioned above
169	**color photos taken**
106	**projection slides prepared**
77	**special enlargements for TV shows and new exhibition material**

The above work was distributed throughout various sections and included both field and office work. Field photography was requested by both Geology and Botany sections in addition to other work. Photographic service was also provided to Archeology, Entomology, Zoology, Museum Education, Exhibits and Preparation Sections. The subject matter varied widely from photos of geologic features of extensive areas to photomicrographs of exceptionally small specimens. In addition, a considerable amount of copy work was undertaken on maps, charts and drawings for slide preparation or illustrations for forthcoming scientific reports.

Various nonroutine assignments throughout the year included work on photos for the new Information Folder and pictures of visitors and guests at the Museum. In addition, photographs were taken or processed for special projects being carried on by the Assistant Commissioner, Assistant Director, Commissioner of Education, Board of Regents and the Division of Archives and History.

Any report of the photographic section should also include the many activities which are present but seldom seen, as is the finished picture. Included in this area are checking and requesting of photo supplies, maintenance and minor repairs of cameras, enlargers and processing equipment.

The work of the special committee on negative files, headed by the Curator of Archeology, is now engaged in cataloging the negatives in the unified files and the Curator has answered several requests for negatives from these files. Several new entries were made in the site record files and maps, and the field negatives for 1956 were cataloged and added to the negative files.

Publications

State Museum and Science Service Series

Benton, A. H. & Krug, R. F.

1956 Mammals and siphonapterous parasites of Rensselaer County, New York. N. Y. State Mus. & Sci. Serv. Bull. 353. Sept. 1956. 22pp.

Chafe, W. L.

1956 Report on Seneca language test administered to children in the Cattaraugus and Red House Indian schools. Prepublication copy for informational use and for critical comment, mimeo. Oct. 1956. 9pp.

Connola, D. P., Collins, D. L., Risley, J. H. & Smith, W. E.

1956 Insect damage and its prevention in windthrown saw timber. N. Y. State Mus. & Sci. Serv. Bull. 352. July 1956. 36pp. 23 fig.

Crocker, D. W.

1957 The crayfishes of New York State. N. Y. State Mus. & Sci. Serv. Bull. 355. May 1957. 97pp. 7 fig. 5 pl.

Dietrich, R. V.

1957 Precambrian geology and mineral resources of the Brier Hill quadrangle, New York. N. Y. State Mus. & Sci. Serv. Bull. 354. March 1957. 121pp. 7 fig. 7 tab. 21 pl.

Friedman, G. M.

1956 The origin of spinel-emery deposits with particular reference to those of the Cortlandt complex, New York. N. Y. State Mus. & Sci. Serv. Bull. 351. June 1956. 68pp. 19 fig.

Ogden, E. C.

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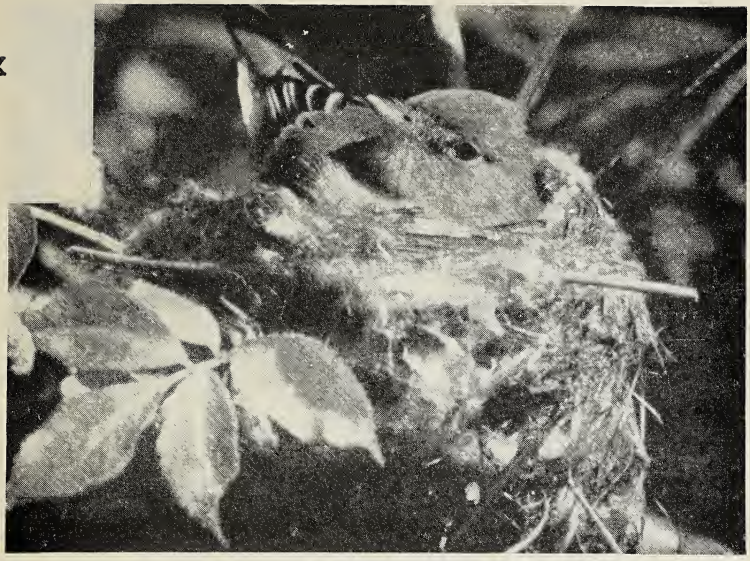

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The Behavioral, Ecological and Morphological Characteristics of Two Populations of the Alder Flycatcher, *Empidonax traillii* (Audubon)

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BULLETIN NUMBER 371

The University of the State of New York
The State Education Department

Albany, N. Y. July 1958

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THE BEHAVIORAL, ECOLOGICAL AND MORPHOLOGICAL CHARACTERISTICS OF TWO POPULATIONS OF THE ALDER FLYCATCHER, *Empidonax traillii* (Audubon)

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INTRODUCTION

The alder flycatcher, *Empidonax traillii* (Audubon), has been a source of much research, discussion and controversy among ornithologists. Many characteristics of this species have been shown to be much more variable than those of other congeneric species, and the extreme expressions represent distinct contrasts to one another (Snyder, 1953; Aldrich, 1951). In the area of central New York, which includes Ithaca, two groups of alder flycatchers recognized on the basis of advertising song are commonly found breeding within hearing range of one another. This study shows how advertising song is correlated to specific behavioral, ecological and morphological characteristics.

Species of birds may extend their ranges as inherent abilities to utilize additional habitats develop. Widely extended distributions may lead to limitations of the flow of genes from one part of the population to the other, resulting in incipient population division and ultimately in two populations. A population divided for a period of time may develop into two or more distinct populations by the reinforcement of existing differences and/or the development of additional differences by mutation and subsequent natural selection or random fixation or loss.

When two such isolated populations develop a secondary contact and become sympatric because of some change of adaptation and/or environment, then the reproductive and ecological isolating mechanisms which have been reinforced and/or developed either may break down and result in merging populations or may serve to keep them distinct.

[1] Holder of Student Honorarium, New York State Museum and Science Service, 1956.

The merging of two populations can be expressed genetically in two ways. In the case of those characters inherited as single alleles, distinct from one another, random recombination of specific characters will take place, while for those characters inherited as a series of genes (quantitative inheritance), it is to be expected that the characters of the parental phenotypes will blend one into the other. There may be genetic restrictions, however, which will keep recombination from exhibiting the full range of possibilities, as has been pointed out in *Nicotiana* by Smith (1950). Two sympatric populations which remain distinct from one another would continue to exhibit the same separate expressions for a series of characteristics that they exhibited before the secondary contact occurred.

If the genetic isolating mechanisms are not strong enough to maintain the distinctness of the populations, this distinctness can be maintained by ecological and behavioral differences which select against mixed pair formation and subsequently reinforce reproductive isolating mechanisms.

Koopman (1950) demonstrated experimentally in *Drosophila* that when two species capable of interbreeding were maintained in a population cage, and the hybrids (the result of mixed pair formation) were selected against (by removal), the percentage of hybrids produced subsequently diminished.

General observations seem to confirm the fact that birds receive stimuli for species and sexual recognition primarily by means of sight and sound, and that the subsequent behavioral responses can serve as important isolating mechanisms. Some groups of birds, e. g. the surface-feeding ducks of the genus *Anas* (Lorenz, 1951), use visual more than auditory stimuli for species recognition and pair formation, with the result that each species has evolved visual signal characters of plumage pattern and associated movements. The sounds associated with courtship, e. g. those of the mallard, *Anas platyrhynchos,* do not carry any great distance, or well. A situation involving both sight and sound in a more balanced proportion may occur in the species of Parulidae, which have highly distinctive, far-carrying advertising songs in addition to highly individual species plumage patterns, especially in the males. In still other species, such as the thrushes of the genera *Hylocichla* and *Catharus* (Dilger, 1956) and probably also *Cisticola* (Lynes, 1930) and *Phylloscopus,* recognition is probably auditory.

Any group of birds using sound instead of sight as a primary means of species recognition probably will exhibit four tendencies: (1) The plumage will show protective coloration, since the selective pressures of predation will act upon the population for protective coloration more

strongly than those for distinct visual patterns to aid in species and sexual recognition; (2) there will be no sexual dimorphism, since the forces mentioned in (1) will be acting approximately the same on males and females; (3) closely related species will have approximately the same plumage pattern, because of common origin, and any morphological variations will be proportional to the adaptation of each species to its environmental niche, and (4) each species will have some distinctive species-specific vocalizations, especially advertising song. This last point is more likely to be true for sympatric than allopatric species, e. g. *Hylocichla* and *Catharus* (Stein, 1956).

This study will attempt to show that certain *Empidonax* flycatchers rely mainly on auditory stimuli for species recognition, and how this has affected their behavior, ecology and morphology.

The author wishes to acknowledge with special appreciation the following people who have contributed to this study: Dr. Arthur A. Allen, Dr. Peter Paul Kellogg, Dr. Robert T. Clausen, Dr. Harold H. Smith, Dr. William C. Dilger and Dr. Richard B. Fischer, all of Cornell University; also Dr. John W. Aldrich, Dr. Stephen W. Eaton, Dr. Heinz Meng and Randolph S. Little, David A. West, Edward L. Seeber, Bernard Nathan, Arthur Schaffner and Harold D. Mitchell. For the loan of museum specimens he wishes to thank the American Museum of Natural History, the National Museum of Canada, the New York State Museum, Ohio State University, the Royal Ontario Museum of Zoology and Paleontology, the United States National Museum, the University of Michigan Museum of Zoology and the University of Wisconsin Museum. For grants-in-aid to support the study he wishes to thank Cornell University and its Laboratory of Ornithology, the National Science Foundation, the New York State Museum and Science Service, and the Chapman Fund of the American Museum of Natural History.

DEFINITION OF POPULATIONS BY SONG

According to Lack (1943), the function of the "advertising song" of birds is to attract females and repel males of the same species. The first function, attracting a mate, occurs when a female hears a singing male, usually on territory, and approaches with the possibility of a pair bond being formed. Hinde (1956) calls this self-advertisement and discusses other possible functions. The second, a form of intraspecific hostility, is used to defend the territory and may ultimately reduce competition among conspecific individuals.

In eastern North America each species of *Empidonax* has a single basic pattern of advertising song except the alder flycatcher, *E. traillii* (Audubon).

The interpretation of song in *E. traillii* has been controversial and varied. The problem is complicated by the fact that two patterns of advertising song can be recognized, and the particular pattern to which different authors refer cannot always be clearly ascertained.

The two patterns, or types, have been arbitrarily called "fee-bee-o" and "fitz-bew." [1] These are perhaps not the best phonetic interpretations and are used only to distinguish between the two. Peterson (1939) was the first author to write that two patterns of song did occur—he called them "fitz-bew" and "way-be-o." Verbal impressions suggest the pattern of the sound, but they do not indicate the detail present in each.

Spectographic analysis, developed originally by Bell Laboratories for studies of speech (Potter, 1946), was readily adapted to the study of the songs of birds. This latter use was suggested by Bailey (1950) and a simplified explanation of the analytic process was written by Borror (1953). The resulting spectrogram is a two-dimensional picture of the sound pattern. As in music, time is represented on the horizontal axis, frequency on the vertical one. The frequency on the spectrogram is measured in a linear scale, rather than the logarithmic scale used in music. The relative loudness of the various parts of the pattern is indicated by the differential intensity of the mark on the spectrogram, constituting a sort of third dimension. However, loudness is not often considered in analyzing bird songs.

Kellogg and Stein (1953) used the sound spectrograph to analyze tape and disc recordings in the Cornell Library of Natural Sounds; showed the contrast between the two patterns of song, and suggested a constancy of each pattern over a large geographical range. Spectrographic analysis of the songs of the alder flycatcher was continued by Stein (1954), who described more of the detail of the song and also other sounds associated with the patterns of advertising song.

A correlation of the phonetic interpretation and the spectrogram for fee-bee-o's is shown in figure 1*a*. The pattern is usually interpreted as trisyllabic. The initial rise and the sharp drop in frequency between the "bee" and the "o" are the most distinct audible characteristics of the fee-bee-o pattern. Although a fee-bee-o's advertising song contains only fee-bee-o patterns, under certain conditions alarm notes of different levels of excitation may be interspersed.

[1] These designations may refer either substantively or adjectively to the song itself or to an individual or population using the particular song, as the sense indicates.

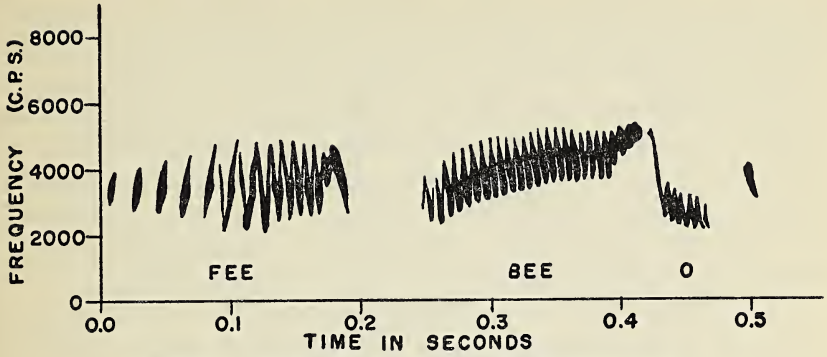

Figure 1*a*. Spectrogram of fee-bee-o advertising song

The "fitz-bew," illustrated in figure 1*b*, usually is interpreted as being disyllabic. There is more variation in patterns and levels of intensity in the fitz-bew than in the fee-bee-o. In contrast to the fee-bee-o, the fitz-bew is interspersed with "creet" notes, originally described by McCabe (1951).

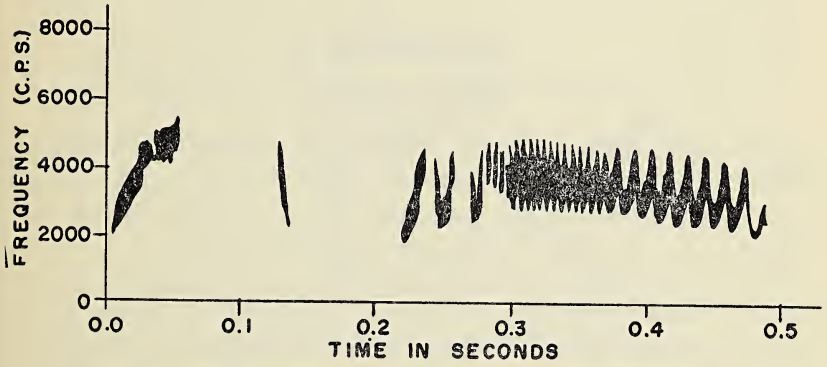

Figure 1*b*. Spectrogram of fitz-bew advertising song

Alder flycatchers, both fitz-bew and fee-bee-o, have notes similar in pattern which are used to express different levels of motivation of the attack-escape drive. The pressures acting upon these notes are not likely to select toward contrasting notes, since there can be mutual benefit both within and among species in warning of a predator or some other cause for hostile encounters.

Combinations of these similar notes can lead to confusion in the field, even though the advertising songs are distinct. An example of this is an individual found by W. W. H. Gunn and recorded by the author which sang what sounded like a series of fitz-bews followed

by a series of fee-bee-o's. The recording was made near Richmond Hill, Ontario, in June 1953, and is now in the Library of Natural Sounds at Cornell University. It contains 12 patterns. Spectrographic analysis showed that the patterns of the fee-bee-o's are typical, and similar to those in figure 1*a*. The remaining patterns, however, are not like the fitz-bew illustrated in figure 1*b*, but were formed by a combination of the alarm notes indicating two levels of motivation, the "pit" and "wee-oo" (for descriptions, see page 18). In the Ithaca area this type of situation has been found on several occasions.

The patterns of the advertising song of the alder flycatcher appear to be as different from each other as from those of other congeneric species. Only one pattern of song each has been described for the least, Acadian, and yellow-bellied flycatchers. For the least, there is the "chebec"; for the yellow-bellied a similar song which spectrographic analysis shows to be slightly more complex. The pattern of the Acadian is somewhat more variable than those of the least and yellow-bellied, according to spectrographic analysis.

METHODS

FIELDWORK

During the summer of 1953 a three-week trip was made through southern Ontario and Michigan to obtain recordings and to note stations where each of the patterns of song could be heard. One weekend also was spent in the Adirondack Mountains.

During the summers of 1954 and 1955, the fieldwork was done among breeding populations within 25 kilometers of Ithaca, N. Y. Several localities within this area had small populations of alder flycatchers, either of one or both of the song-types. These localities are: Fleming Meadows, the Hog Hole, East Ithaca, Michigan Hollow Beaver Pond, the Horse Pasture, East Hill Airport and Etna Substation. Other alder flycatchers were observed at North Spencer Marsh and Dryden Lake. All localities are shown in figure 2. Detailed descriptions of them may be found in appendix I. The season extended from the time the alder flycatchers arrived in mid-May until mid-August when the birds became very quiet and the southward migration had started. In 1956 the early part of the season was spent collecting birds near Ithaca, Olean and Buffalo, N. Y., with one short trip to the Hudson River Valley. From about mid-June until August 1, the study was similar to those made in 1954 and 1955.

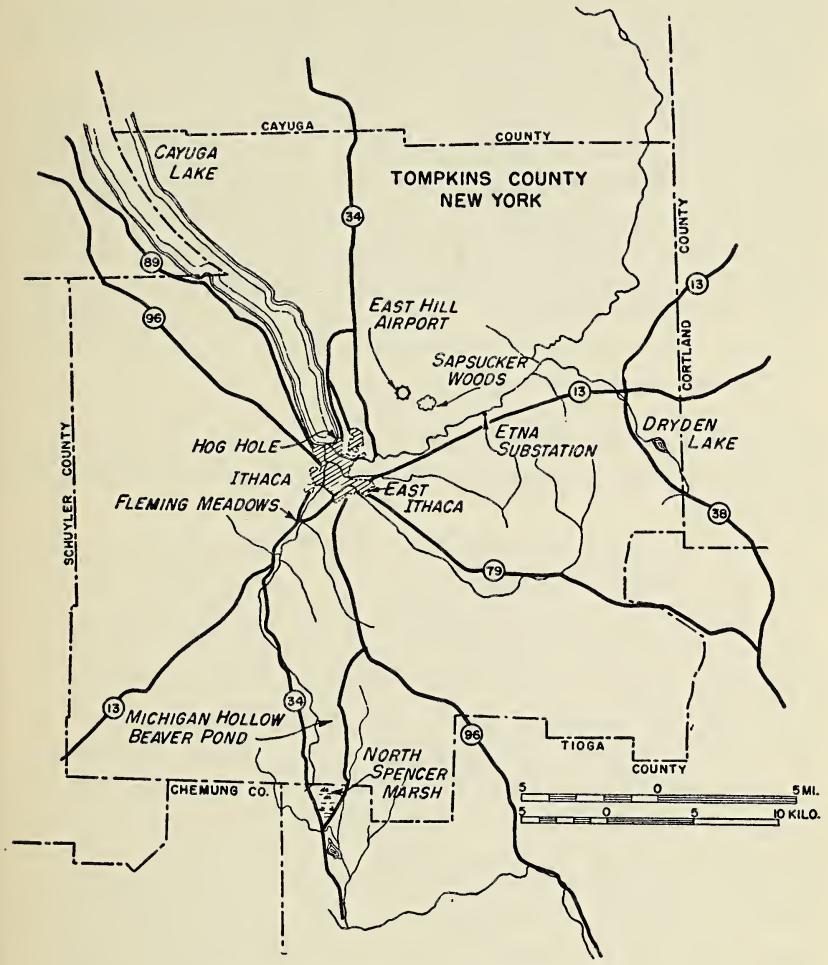

Figure 2. Map of local areas of study

BEHAVIOR

Some measure of the distinctness of the song-types, from the viewpoint of the flycatchers, was obtained by experimental use of playback of songs in the field. Theoretically, playback of the advertising song can be used to test the reactions of both male and female. However, this study is concerned with the males' recognition of and reaction to territorial invasion by a conspecific "singing bird" (playback).

In this study experiments were done only in the field for three reasons: (1) A larger sample is possible; (2) under natural conditions the function of song as an isolating mechanism or character for the recognition of species is responded to in a typical way. Under artificial

conditions these isolating mechanisms frequently breakdown. This is well recognized in ducks. (3) The problem of keeping small flycatchers in captivity has not been sufficiently perfected.

The recordings were played on a Magnemite tape recorder-reproducer which had a self-contained battery and a spring-wound mechanism for moving the tape. A small, battery-operated amplifier was used to power one small speaker, which was put in each bird's territory. Both reels and loops of recorded sound were used. During 1955, the sound was played from five-inch reels of tape, which allowed about eight minutes of playback before rewinding. In 1956, loops containing one song, either a fitz-bew or fee-bee-o, were used at first, in an attempt to eliminate the problem of rewinding. While this technique proved satisfactory for fee-bee-o's, the fitz-bews did not react as strongly to the fitz-bew pattern alone as when the "creet" note was interspersed, making a sequence too long for a loop. Therefore, for fitz-bews, the reel was needed.

The advertising songs of the two types of alder flycatchers, and the least and Acadian flycatchers were used. The latter two, used on a more limited scale than the others, provided comparable data on responses to other well-recognized species. During the playback, a three-dimensional papier mache model, painted with oil color to look like an *Empidonax* flycatcher, was also set up close to the speaker.

Forty-nine separate experiments were made with fitz-bews on territory and 36 with fee-bee-o's. The procedure for each experiment was to start with a recording of the opposite pattern of song of the alder flycatcher or the song of the Acadian or least flycatchers. After one or more of these had been played, the bird's own song was used. A positive reaction to this playback assured that the sound could be heard. Then, after a lapse of time the opposite pattern of song was replayed to determine the reaction again. Occasionally, playback of the song of one of the other two species was used between these two to determine that the threshhold of response had returned toward normal enough to procede. Additional information regarding the variations in response was obtained from observing natural encounters.

In making many separate experiments on a limited population, it is necessary to consider the problem of habituation, or "the waning of a response as the result of repeated stimulation which is not followed by any kind of reinforcement" (Thorpe, 1951). Because of its enduring nature, habituation results in a lack of response even with the releaser functioning normally. This problem has been minimized by playing songs back to as many individuals as possible and allowing a lapse of three weeks between the repeats that were necessary.

The interpretation of behavior is derived from Lorenz (e. g. 1951) and Tinbergen (e. g. 1951). The stress is on the balance between drives, such as attack and escape, and the concept of releasers as applied to innate behavior.

The degrees of intensity of reaction were determined by first judging the extreme forms, e. g. the chase and fleeing, mentioned later, and then interpolating the intermediate stages from the context of the reaction and analyzing the shift from one movement or sound to the next. Since the data permit only the organization of a qualitative, sequential series, the degrees of difference between any two adjacent responses may or may not be equal.

ECOLOGY

The objective of the ecological analysis in this study was to ascertain some of the relationships of the alder flycatchers to the vegetation in their territories, and probably the most direct contact of a bird with this vegetation comes at the site of the nest. Because a generalized analysis of habitat in an area where the two song-types occur sympatrically might obscure ecological differences, the sample of the habitat and substrate was directly related to the site of the nest.

Concentric quadrats (samples arbitrarily chosen to be 5 and 10 meters square) were outlined around each nest with the nest in the approximate center. In the 5-meter quadrats the percentage of cover of each species of shrub was determined and all species of herbs were noted. In the 10-meter quadrats only the common shrubs were noted. In each case the species of shrub in which the nest was located was designated and the height of the nest above the ground was measured, from the rim perpendicular to the ground, to the nearest inch and converted to centimeters.

The shrubs in the 5-meter quadrats were then classified, each according to its percentage of total cover in the quadrat, according to that of Braun-Blanquet, as suggested by Oosting (1948):

Class	Percentage of total cover
1	0-5
2	5-25
3	25-50
4	50-75
5	75-100

The nomenclature for plants is that of Clausen (1949).

After the birds had abandoned it or the young had fledged, the nest was collected and a copper tag marked with the number of the nest

and date of collection was wired to the branch from which the nest was taken. The nests were numbered consecutively for each year of the study (e. g. 55-2, 56-8), and the number used to refer to any observation concerning that territory. After the nest was collected, the inside depth and diameter were measured to the nearest millimeter, the outside depth and diameter to the nearest five millimeters. When the nest was not circular as viewed from the top, an average of two axes measured perpendicularly to one another was recorded.

During 1955, when a nest was found containing eggs, the eggs were measured with dial calipers which were calibrated to read directly to the nearest 0.1 mm. Readings were taken on the greatest length and diameter. This was done by putting each egg between the plane surfaces of the calipers. When the egg would not pass between the planes, the calipers were opened 0.1 mm. at a time until the egg could just pass through, avoiding any pressure on the eggshell. This measurement was then recorded. One egg from each nest was retained as a specimen. Egg color was determined by direct visual comparison of the collected eggs.

The average size of the territory for individual birds in six areas of concentrated study was determined by dividing the area occupied by each local population, estimated from the United States Geological Survey's 7.5-minute series of topographic maps, by the number of territories known to occur there. No allowance was made for unsuitable or unoccupied areas that may have occurred between the territories.

The analysis of results obtained by the quadrat method has been done both by local populations and by song-types, since three relationships are possible: pure fee-bee-o, mixed, and pure fitz-bew populations. Where possible, statistical analyses were made. The differences between the means of both length and diameter of eggs of the two song-types were analyzed for significance using the "t" test (Snedecor, 1946, p. 81).

Data have been accumulated from four sources regarding the geographical distribution of song-types: (1) recordings on discs or magnetic tape personally classified to song-type; (2) personal aural interpretation in the field; (3) aural interpretation by persons whom the author knows from experience can distinguish between the two types, and (4) selected literature.

MORPHOLOGY

Specimens of known song-type were assembled from various museums and were augmented by personal collecting. One series contained 31 known adult fitz-bew males, the other 38 known fee-bee-o

males. The locality and dates of collection, and measurements of the characters cited may be found in appendix table 1.

Since the purpose was to correlate only song-type to morphology, personal collecting was limited to birds which were heard singing, whether or not they were breeding birds. Even though most of the specimens from the Ithaca area were not collected during the breeding season, the fitz-bews must represent breeding birds from this or nearby areas, since central and western New York State are near the northeastern extremity of the range of fitz-bews. The fee-bee-o's collected in this area represent either breeding birds or migrants which go north and east toward the Adirondack Mountains and Canada.

The measurements were made with a dial caliper, the same as was used for measuring eggs.

The measurement of most characters involving feather length is complicated by the problem of feather wear. This is particularly critical when the differences are very slight and large ranges of overlap between two series of specimens exist. These complications can be lessened by using specimens collected within a limited season of the year.

The chord of the wing was measured to the nearest millimeter from the joint of the wrist of the folded wing to the end of the longest primary, usually the second or third from the outside. This measurement can vary if pressure is applied on the arc of the wing during measurement. Therefore care was taken to avoid any pressure. It is also often difficult to determine accurately the proximal end of the metacarpals in the folded wing. These problems can influence the significance of differences found between the song types.

The length of the tail was measured to the nearest 0.5 mm. from between the points of insertion of the central rectrices to the tip of the longest rectrix.

The length of the tarsus was measured from the hind indentation of the tibiotarsal-tarsometatarsal joint to the distal edge of the last complete scale of the acrotarsium. This particular measurement was often complicated by the fact that the last scale was often indented, but not broken, and that the pattern of the scales in this region is not constant within either song-type. Measurements were checked under a seven-power binocular microscope.

The bill was measured from the anterior point of the nostril to the tip of the bill. One point of the calipers was set at the anterior point of the nostril and the length of the bill was then read to the nearest 0.05 mm. where the other point just passed the tip without contact. These measurements were also checked under a seven-power binocular

microscope. The length of the culmen was not measured, since the point at which it blends into the forehead is not precise.

Statistical terminology and analyses follow Snedecor (1946), used previously for egg measurements.

The color was judged by assembling a series of breeding birds from North and South Dakota, including the type of *E. t. campestris* Aldrich (1951) and from New Hampshire, Maine and New Brunswick, including the types of *E. t. alnorum* Brewster (1895) and the type of *E. t. traillii* (Audubon, 1831) at the United States National Museum and comparing these directly, and at one time, to each other and to the series of birds of known song-type.

BEHAVIOR

The role of territory in the life of a bird has been summarized by Howard (1948) and more recently by Hinde (1956).

Each spring the male alder flycatchers apparently arrive before the females. In Ithaca, fitz-bews arrive about the third week of May, fee-bee-o's somewhat later. Upon arrival on the breeding areas, they set up potential territories, which are adjusted in size and shape according to the pressures of the incoming population and the amount of available habitat. When the females arrive, they respond to the singing of the males of their own species, potential mates, with whom they form pair bonds. The behavioral patterns associated with the formation of the pair are not known for either fitz-bews or fee-bee-o's.

After the bond has been formed between the male and female, the pair defends its territory from intrusion by other conspecific individuals, which are apparently recognized almost exclusively by sound. When this occurs, hostile behavior is elicited by the territorial bird(s) who tries to drive away the intruder by intimidation. This is usually done through movements and/or sound which serve as releasers and are often highly ritualized. Physical contact is probably used only after these methods have failed.

In the experiments using playback, therefore, one would expect hostile behavior to result when the individual on territory recognizes the intruder (the sound coming from the speaker, with or without the model) as a conspecific competitor on its territory. However, it should not react to the songs of other species. A summary of the results of such experiments might thus be used to indicate the degree of relationship, and conversely that of isolation, between the two groups.

DEFINITIONS

Before describing and comparing the various behavioral responses, it is necessary to define a number of terms.

Displacement activity: An activity which belongs to the motor pattern of an instinct, other than the one(s) activated. These activities result when two opposable drives are activated simultaneously, and one is thwarted by the other (Tinbergen, 1952).

Display: Any stereotyped auditory, visual or other characteristic of an animal which serves a signal function (Dilger, 1956).

Drive: A term synonymous with motivation. Motivation (Tinbergen, 1951) is the activation of an animal's instincts. The response takes place when the threshold is reached.

Hostile behavior: Also referred to as attack-escape behavior in this study. Moynihan and Hall (1954) stated that hostile behavior "includes all the activities resulting from a tendency to attack and/or escape. This conjunction is due to the fact that the same objects or animals, at different times and in different circumstances, may stimulate any one, or all, of the different hostile patterns. It is possible, indeed, that all such objects and animals always activate both attack and escape motivation (although often very unequally, thus explaining many of the cases in which only one type of motivation is outwardly expressed)."

Releasing mechanism: "A special neurosensory mechanism that releases the reaction and is responsible for its selective susceptibility to a very special combination of sign stimuli" (Tinbergen, 1951).

Releaser: Any one or more signal features presented by an object or animal which stimulates an innate response (Dilger, 1956).

Ritualization: The process by which movements are secondarily adapted to the function of a social releaser (Daanje, 1950).

Sign stimulus: The signal produced by the releaser which activates the appropriate RM (Dilger, 1956).

HOSTILE DISPLAYS

The following movements and sounds represent hostile responses:

Chase: The actual pursuit of one bird by another.

Crest raising: This is an erection of the feathers of the top of the head to various degrees. It makes the bird's head appear larger and apparently occurs when the attack drive is stronger than the escape drive.

Spread: The lateral erection of the feathers of the breast, causing the breast to appear larger. It was frequently accompanied by a raising of the back feathers, and the tail was usually held in an almost vertical

position, but not spread laterally. The crest raising, which always preceded the spread, was also continued. This display apparently occurs when the attack drive is more strongly activated in proportion to the escape drive than in crest raising.

Tail pumping: This movement of the rectrices in the vertical plane had its emphasis on the forward stroke, under the body. From the forward position the tail was returned to the normal angle, in a straight line with the back, at a much slower rate. This action seemed to indicate the condition where the attack drive was only slightly stronger than the escape drive.

Three kinds of sounds were heard which appear to represent increasing levels of actual intensity of the attack-escape drive: the pip (or "pit") note, the wee-oo note and the churr.

Pip note: This note is the sound first heard upon approaching a nest. It was heard from both fitz-bews and fee-bee-o's, although there seemed to be a slight difference in sound quality between the two. It blended into the next higher level, the wee-oo, with the transition marked by a change of relative frequency.

Wee-oo note: This note has a high initial frequency and ends with a long note which decreases slightly in frequency. It is several times longer than the "pit."

Churr: This is a sound which frequently seemed to be a series of pits at low volume which always seemed to end with either a wee-oo note or some low-volume song-like notes.

COMPARATIVE HOSTILE BEHAVIOR

The general pattern of reaction for both fee-bee-o's and fitz-bews is summarized in figure 3. This chart shows the variation in reaction as an expression of two variables: (1) the actual strength or intensity of the response (represented on the vertical axis) and (2) the intensity of activation of the attack and escape drives relative to one another (on the horizontal axis). It represents only a qualitative sequence of behavior, following the pattern used by Dilger (1956) for analysis of behavior in *Catharus* and *Hylocichla.*

The actual level of intensity of the hostile motivation was an expression of the internal factors, such as the stage in the reproductive cycle, and the external factors, such as the strength of the releaser and sign stimuli, acting together. The relative intensity of attack to escape is also controlled by these two factors, but the immediate changes of external sign stimuli may be more important.

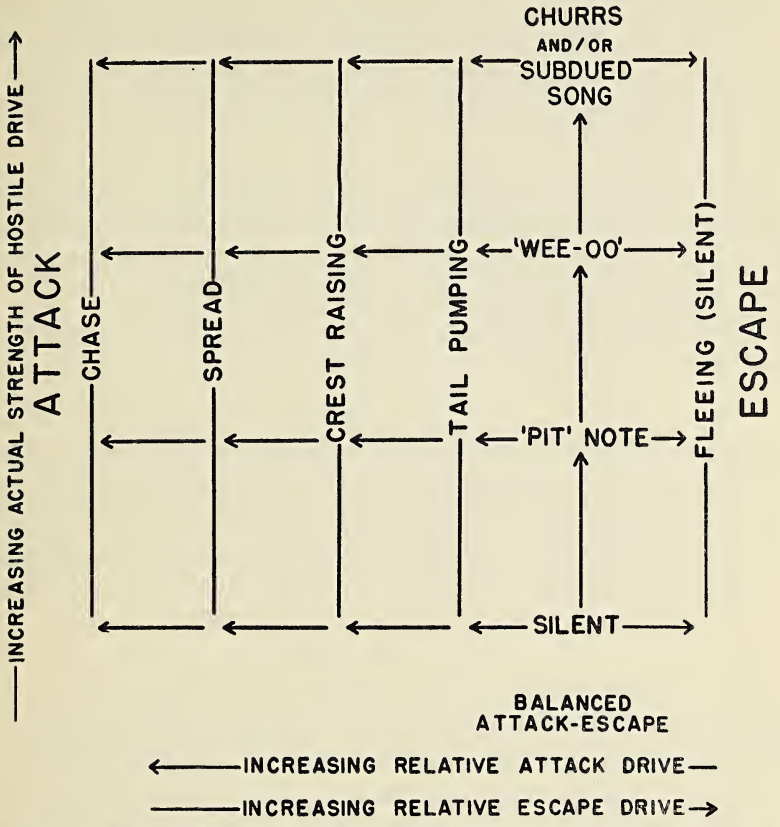

Figure 3. Proposed diagram of hostile behavior patterns of fitz-bew and fee-bee-o alder flycatchers

RESPONSE TO OWN PATTERN OF SONG

The fitz-bews and fee-bee-o's responded to the playback of their own songs as they would be expected to react to a conspecific territorial invader. Almost every intersect of the two variables in figure 3 was observed. Generally speaking, however, the fee-bee-o's showed fewer cases of high intensity and used churrs less frequently. The hostile behavior observed manifested itself in three types of reactions: attack, escape and displacement.

Attack

The lowest level of vocal response related to attack is the "pit" note. On June 17, 1955, a fee-bee-o at the airport responded in this way:

> 55-11. 6:29 a. m.—Started fee-bee-o (playback). After five songs were heard, fee-bee-o on territory flew down, apparently

from the telephone wire, and landed in tall willows about four meters from the speaker and model. It gave "pits" regularly between most songs from the playback, but not after every one. It did not sing its advertising song and made no motion to move closer to the model.

Pit notes also were used when the bird approached the nest, sometimes in rapid succession, sometimes with long time intervals between Sometimes when the playback was stopped, the territorial bird gave a series of wee-oo notes, occasionally followed by a churr.

A reaction of low intensity was shown by a fitz-bew at Fleming Meadows on July 3, 1955:

55-21. 9:16 a. m.—Started fitz-bew playback. After about 10 seconds the bird flew into the clump of sumac, right over our heads. The bird moved closer to the speaker and model, then moved off and circled about 2.5 meters from the model. Recording stopped. 9:20—Started fitz-bew again. Bird moved around, excited, pumped tail. Bird sang fitz-bew twice, was then frightened off by a flicker. The alder flycatcher was then seen on wire above shrubs and was heard giving pits, pumping its tail with each note.

Still stronger reactions were obtained from fitz-bews during the period of incubation in territory 55-2 on June 25, 1955, at the Hog Hole, and in territory 55-13 on July 3, 1955, at Fleming Meadows:

55-2. 7:20 a. m.—Start fitz-bew. Bird flew past speaker at about three meters, flew across road and up to wire, where it began a rapid series of creets and fitz-bews which sounded more insistent than the playback. The bird moved closer to the speaker, perched in a cottonwood and continued to sing. The other bird came from the nest to the cottonwood, gave wee-oos and then churrs. One bird went behind the tree. The other bird raised its crest and gave pits and wee-oos in competition with the playback. The recording was stopped and both birds flew off. After a short time interval the recording was played again. After 14 seconds the bird flew to the wire and gave one wee-oo. Then it flew to the cottonwood and gave churrs. The second bird gave a few notes from the other side of the tree. Both birds flew across the road. One gave fitz-bews, rapidly and with emphasis, raised crest, spread breast feathers laterally. After moving around, both birds flew up to the wire, where one sat quietly. The other bird had a raised crest, spread breast feathers and sang fitz-bews.

55-13. 7:59 a. m.—Start fitz-bew. Bird in willow moved immediately toward model and speaker, but stayed in the same bush. The bird moved around in the bush giving pits. Raised crest. Both birds flew past model. The one which remained in sight was excited, pumped tail, raised crest. Finally flew to wire.

The response of one pair of fitz-bews, whose clutch was only partly laid, gives additional detail regarding high level responses:

> 55-20. 8:02 a. m. (July 6, 1955)—Start fitz-bew recording. The bird flew from a low perch in the shrub containing the nest and gave a goldfinch-like "yip-yip." It landed in a hedgerow along the gravel road and gave pits and wee-oos. The bird then flew and landed in a shrub behind the one with the nest. The recording was stopped for 20 minutes and then started again. The recording started with a creet. On the following fitz-bew the bird flew at the model, swooped and flew off. Fifteen minutes elapsed. Bird flew past the speaker and model at a distance approximating one meter and returned to the shrub containing the nest, from which it gave a series of churrs. Both birds were excited and were moving around but remained low in the bushes.

On many occasions the fee-bee-o's stayed more than 10 meters from the speaker, often remaining out of sight and singing in competition with the playback, though actual attack by flying past the model was also fairly common. In contrast to natural encounters where one bird chased the other, making churrs or other sounds, flight past the model was without sound.

Escape

When the drive to escape is stronger than the drive to attack, the bird flees, apparently silently. It is not known whether the escaping bird is always chased nor what escape behavior directly precedes the act of fleeing, though pressing the plumage tightly to the body is a known fear response. Escape has been observed in both fitz-bews and fee-bee-o's and in natural encounters only.

Displacement

On May 28, 1955, at the East Hill Airport the behavior of a fee-bee-o showed a displacement type of activity:

> 55-17. After a short period of playback of fee-bee-o song, the bird flew past the speaker. It moved around in the bushes, answering the playback with songs. It came within two meters of me and sang fee-bee-o. The bird made two more flights past the model, but showed no other signs of hostile behavior. After that it never approached the model more closely than five meters. It hardly left the protection of the bushes but was seen bill-wiping at several perches.

The bird was apparently motivated to attack by the song coming from the speaker, but for some reason (perhaps that the songs were

loud enough to intimidate the bird), the escape drive was also strengthened. This resulted in a displacement activity.

A fitz-bew performed bill-wiping in a similar manner on June 25, 1955:

> 55-3. 10:10 a. m.—Bird on wire. Start playback of fitz-bew. After 30 seconds the bird dropped straight down and flew past the model and into a nearby *Cornus*. 10:13—The bird has been moving around in the *Cornus,* pumping its tail continuously. The bird flew up to the wire with food in its bill. The bird flew down again into the shrubs and went back and forth past the model several times. When perching in the shrubs, it pumped its tail about twice per second and continuously wiped its bill on the branches. After the recording was stopped, the bird flew into the bush with the model, stopped momentarily and flew off.

After the stimulus of song had been stopped, the escape drive seemed to diminish and the bird approached the model, if only momentarily.

RESPONSE TO OPPOSITE PATTERN OF SONG

Negative responses were obtained in each of the 36 cases in which the song of a fitz-bew was played to a fee-bee-o bird. Of the 49 playbacks of fee-bee-o to fitz-bew birds, 46 gave negative reactions. A response was considered negative when the bird either showed no sign of being disturbed or flew off to another part of its territory and intimidation was not indicated by the context of the flight.

In two of the remaining three cases, playbacks of fee-bee-o's not only preceded but also followed playbacks of fitz-bews. The first playback gave a negative reaction, but apparently because the interval between the playback of the fitz-bew and the later fee-bee-o was too short, the bird's RM threshold of response had been lowered, and a subnormal releaser (the opposite pattern of song) caused a positive response.

The third positive reaction to this experiment occurred on July 3, 1955, at Fleming Meadows. One bird was incubating at the time. The following notes were taken:

> 55-13. 8:30 a. m.—Speaker and model set up in sumac where alder flycatcher was seen. Fee-bee-o playback started. The bird was seen after 15 seconds when it flew toward the sumac, turned and flew away past the model. It returned to a nearby bush and gave several wee-oos. The recording was stopped. The bird remained in the general area giving pits and some rapid series of pits and wee-oos.

The bird reacted to the fitz-bew playback which followed by flying past the model within one meter and raising its crest. This playback

was followed by one of chebec after about seven minutes. During this latter playback the bird sat quietly and looked around. It finally gave a wee-oo and left, after which the recording was stopped.

RESPONSE TO SONGS OF ACADIAN AND LEAST FLYCATCHERS

The song of the Acadian flycatcher was played back three times to fitz-bews; the chebec of the least flycatcher 12 times to fitz-bews and four to fee-bee-o's. Negative reactions were observed in all cases, although the recordings were played for at least one minute each time.

In territory 55-8 a least flycatcher could be heard singing chebec quite frequently from the small trees about 25 meters east of the nest. This least flycatcher was heard on several occasions, but never seemed to elicit a response from the fitz-bew at any time. The fitz-bew did not react to the playback of the chebec or of the fee-bee-o.

REACTIONS OF THE FEMALE

Generally it was not possible to distinguish between male and female. Singing birds were considered males, since females are not known to sing. The sex of quiet birds could not be determined unless obviously incubating females were seen or they were accompanied by singing males. However, on June 25, 1955, the following notes were taken:

> 55-2. 7:32 a. m.—(During incubation period). No birds in sight. Start fitz-bew recording. After 14 seconds bird flew to wire and gave one wee-oo, then it flew to a nearby cottonwood where it gave a few odd notes. A second bird gave a duet with the speaker from the telephone wire. Both birds then flew across the road. One bird gave fitz-bews, rapidly and with emphasis and raised its crest and spread its breast feathers laterally. After moving around for a short while, both birds flew up to the wire. One sat quietly and spread no feathers, while the other raised its crest, spread its breast feathers and sang fitz-bews. The recording was stopped. The birds flew off. After a few seconds one bird returned, gave a single wee-oo and flew off again.

In this particular case it appeared that the female was less responsive to playback than the male. In other territories known females have been observed giving pit notes and possibly wee-oo's, but none of the movements described for males can definitely be assigned also to females.

ECOLOGY

The fitz-bew and fee-bee-o populations of the alder flycatcher may have originated from a common ancestral population which may have

been divided into separate populations as a result of adaptation to different environments and subsequently become sympatric secondarily in the central New York area.

Aldrich (1953) wrote that "the western prairie population of Traill's flycatcher was formerly more completely isolated from the eastern boreal population, but has recently come into closer contact by infiltration from the west along the plains of the Great Lakes, since removal of the original forest cover has produced more satisfactory habitat for it." This explanation does not consider the line of contact that occurs westward to Wisconsin and almost surely to the west coast. Instead, a series of populations may form a gradual transition, a "rassenkreis," from the fitz-bew to the fee-bee-o types, and the extreme forms come together in the east.

The various adaptations to the environment may be considered as biological characters, independent of one another within the limitations of earlier discussion.

GEOGRAPHICAL RANGE

McCabe (1951) attempted to classify the phonetic interpretations of the songs of the alder flycatcher which he found in the literature into di- and trisyllabic patterns to see if there was a geographical correlation. He found none. Aldrich (1953) felt that some of McCabe's interpretations were open to question. He wrote: "In any case we know from specimens and field observations that both the pale interior prairie type with the *'fitz-bew'* song and the dark northeastern and highland type with the *'way-be-o'* song breed in close proximity today in western New York State, and the correlation of their distribution with the sinuous boundary between plain and plateau results in extremely interdigitated ranges."

Using the physical divisions of the United States as outlined by Fenneman (1946), the distribution of the song-types is as follows (see map, figure 4):

1. New England Province—typically fee-bee-o's, including records in Maine (Palmer, 1947), eastern Massachusetts (Farley, 1901) and North Greenwich, Conn. Both types migrate along the Hudson River near Bear Mountain.

2. Adirondack Province—fee-bee-o's at Chubb River Swamp, Paradox and Elk Lakes.

3. Coastal Plain—fitz-bews at Stuttgart, Arkansas (Meanley, 1952).

4. Valley and Ridge Province—both types migrate along the Hudson River near Poughkeepsie.

Figure 4. Geographical distribution of known patterns of song

5. Appalachian Plateaus—primarily fee-bee-o's near northern extremity with records in New York State for Ithaca area (where fitz-bews are replacing fee-bee-o's), South Vandalia (Mount Moriah Swamp), Machias (Beaver Meadows), Wyoming County (Buffalo Audubon Society Sanctuary) and Catskill Mountains (Parkes, 1954); fitz-bews at Lew Beach (Fischer, personal communication). The song-type found in this province, south of New York State is unknown. Both types are known to occur in contiguous breeding territories along the edge of this province and the Central Lowlands in Cattaraugus, Erie and Niagara Counties, N. Y.

6. Central Lowlands—fitz-bews in all but the northeastern part, where fee-bee-o's are almost exclusively found. Both types occur along the southern edge of the Niagara Peninsula from Fort Erie west to Dunnville, Ontario, and probably further west. Fitz-bews are known to have bred in Lucas County (Campbell, 1936) and Columbus, Ohio (Henshaw, 1876); Point Pelee and Pelee Island, Ontario; Ann Arbor, Mich. (Berger and Hofslund, 1950); Madison, Wis. (McCabe, 1951); along the James River in South Dakota (West, personal communication) and the Lower Souris Wildlife Refuge, Upham, N. D. (Allen, personal communication). Fee-bee-o's are known to have bred near Cheboygan and Macmillan, Mich., and near Sudbury, Vermillion River, North Bay, Algonquin Park and Toronto, Ontario. A recording of a fee-bee-o from south of Minneapolis, Minn., may not be of a breeding bird.

7. Great Basin—fitz-bews breed in the Bear River Marshes in Utah (Allen, personal communication).

8. Columbia Plateau Province—most likely fitz-bews breed near Pullman, Wash., on the Palouse Prairie (King, 1955).

9. Pacific Border Province—fitz-bew (or slight variation thereof) was recorded at Friday Harbor, Wash. The recording is now in the Cornell Library of Natural Sounds.

Just how far north the fitz-bews are found and where they meet the fee-bee-o's whose range extends west from New England to Alaska is not known, but the area of contact is probably somewhere in southern British Columbia.

In the Ithaca region, the status of the song-types is changing, with the fitz-bews apparently displacing the fee-bee-o's. Until about 1940 only fee-bee-o's were known to occur in Ithaca, according to Dr. Allen. Sometime after that the fitz-bews replaced the fee-bee-o's at Fleming Meadows. Migrant fee-bee-o's have been heard there, but during this study none were known to breed there. There is some evidence of a change of habitat (see page 28).

A population of fitz-bews was known on the Cornell University campus, north of Cascadilla Creek. This appeared to be the situation in 1954. In 1955 a fitz-bew was found nesting on the east side of the East Hill Airport; in 1956 one fee-bee-o territory had been taken over by a fitz-bew, several individual fitz-bews were known in the area, and a small colony of fitz-bews was found for the first time near the terminal of the airport. Two years previously only fee-bee-o's were known by the author to occur there.

Whether the fitz-bews first occurred in the low areas south of Cayuga Lake because of the vegetation and/or because of the location cannot be assessed. The area of the Inlet Valley near Cayuga Lake, including Fleming Meadows and the Hog Hole, would seem a logical point for the first establishment of a new colony of fitz-bews.* This area is at the north end of the Inlet Valley, with the Susquehanna drainage to the south and the Ontario Plain to the north, at the opposite end of the lake. Both areas contain fitz-bew populations, from either of which local fitz-bews could have been derived.

SIZE OF TERRITORY

To determine the approximate proportion of each bird's territory which the 5- and 10-meter quadrats covered, the size of the entire territories was estimated for each of six local populations studied. The average estimated size of territory for each of these areas is as follows:

TABLE 1

Estimated size of territories

FITZ-BEW SONG-TYPE	SIZE OF TERRITORY	QUADRAT: TERR. SIZE
Fleming Meadows	±0.018 sq. km.	5.6%
Hog Hole	±0.012 sq. km.	8.3%
East Hill Airport	±0.011 sq. km.	9.1%
FEE-BEE-O SONG-TYPE		
Horse Pasture	±0.030 sq. km.	3.3%
Michigan Hollow	±0.015 sq. km.	6.7%
Etna Substation	±0.013 sq. km.	7.7%

The total of the individual territories may not have filled the entire area, although the degree to which this is true was not ascertained.

* At the southeast corner of Cayuga Lake, slightly over a kilometer from the Hog Hole, tufted titmice (*Parus bicolor*), Carolina wrens (*Thryothorus ludovicianus*), and blue-gray gnatcatchers (*Polioptila coerulea*) have nested in the woods in recent years.

The 10-meter quadrat represented an estimated 5.6 to 9.1 percent of the total of each fitz-bew territory, and 3.3 to 7.7 percent of each fee-bee-o territory; the five-meter quadrats one-fourth of these figures.

HABITAT

General descriptions of the habitat of the alder flycatcher have been published on several occasions. However, even those published after Peterson described the song-types in 1939 usually are not detailed enough either in describing song-type or habitat to make very critical comparisons.

The general habitat for presumed fitz-bews has been described in Ohio near Columbus (Henshaw, 1876), Lucas County (Campbell, 1936), Buckeye Lake (Trautmann, 1940); in Arkansas (Howell, 1911), and particularly near Stuttgart (Meanley, 1952); near Ann Arbor, Mich. (Berger and Hofslund, 1950), and Madison, Wis. (McCabe, 1951). The general habitat of fee-bee-o's was described from eastern Massachusetts (Farley, 1901); New York, probably the Adirondack Mountains (Eaton, 1911); Maine (Palmer, 1947), and Hatley, Quebec (Mousley, 1931). King (1955) does not make clear to which song-type he is referring. Snyder (1953), reviewing several papers, concluded that both populations showed a wide tolerance with regard to drainage, the southern populations (fitz-bews) possibly using dry areas more frequently.

In the part of this study conducted at Fleming Meadows, the nests were regularly found in the lower, more poorly drained areas. In these low areas were *Typha latifolia, Salix nigra, S. sericea, Cornus alba* and *Sambucus canadensis*. The drier, more elevated portions still showed evidence of an abandoned apple and peach orchard. Some birds used this latter area for foraging and for finding material for nests. Another part of the Meadows was a fallow field which had much *Asclepias incarnata* throughout and was adjacent to a large stand of *Carex riparia*. *Sambucus* and *Cornus* were the dominant shrubs.

The area of Fleming Meadows in which the study was made did not include the part on the east side of the Inlet Valley, east of Highway 13. This area contains extensive alder thickets and cattail marsh and is a part of Buttermilk Falls State Park. Only fitz-bews were heard there during the breeding season. The entire Fleming Meadows apparently has been opened up and the extent of the alder swamp reduced by the creation of both fields and roadbeds. The number of larch trees has been reduced until only a few remain.

At the Hog Hole some nests were found in dry fields, created by fill for a railroad bed. *Sambucus, Salix* and *Prunus* were common. The lower swampy area was covered with *Typha, Lythrum* and sedges.

Table 2 contains a summary of the shrubs present in the individual quadrats in these two areas. Appendix table 2 contains data for the individual quadrats.

Occurrence of the four most common genera in these quadrats was: *Sambucus,* 60.8 percent; *Cornus,* 60.8 percent; *Rubus,* 56.5; *Salix,* 43.5. Only one species of *Sambucus—canadensis*—was present. The other three genera were represented by three species each.

TABLE 2

Summary of frequency of occurrence and average rating of cover of shrubs in 10- and 5-meter quadrats respectively—fitz-bews

	10-METER QUADRATS		5-METER QUADRATS	
	NO.	FREQUENCY (%)	NO.	AVERAGE RATING OF COVER
Fleming Meadows, Hog Hole (n=23)				
Cephalanthus occidentalis	1	4.3	1	0.17
Cornus alba stolonifera	12	52.2	10	1.09
amomum	1	4.3	1	0.09
racemosa	3	13.1	3	0.39
Prunus virginiana	7	32.2	1	0.09
Pyrus malus	2	8.7	0	0.00
Rhus typhina	6	26.1	3	0.27
Rubus allegheniensis	1	4.3	1	0.17
idaeus strigosus	11	47.8	7	0.65
occidentalis	2	8.7	2	0.17
Salix fragilis	4	17.4	0	0.00
nigra	5	21.7	5	0.74
rigida	1	4.3	1	0.09
Sambucus canadensis	14	60.8	14	1.78
Ulmus americana	1	4.3	0	0.00
Vitis vulpina riparia	4	17.4	2	0.17
Upland (n=4)				
Cornus alba stolonifera	2	50	1	0.75
Cornus racemosa	3	75	2	2.00
Crataegus (?filipes)	2	50	2	1.25
Prunus virginiana	1	25	1	0.25
Rhus typhina	1	25	0	0.00
Salix discolor	1	25	1	0.75
nigra	1	25	0	0.00
Viburnum dentatum	1	25	1	0.50

Upland populations of fitz-bews occurred at North Spencer Marsh, Dryden Lake and East Ithaca. The birds nested in areas of poor drainage near the outlets of the first two. The shrubs containing nests were near wet fields, probably kept that way by seepage from the outlets. Table 2 includes a summary of these quadrats, appendix table 2 the information for individual ones.

At East Ithaca, the birds nested in relatively dense shrubby fields, dominated by *Crataegus* and *Cornus racemosa.*

An area on the Cornell University campus similar to the one at East Ithaca has been destroyed by filling it in. It originally comprised the slope north of Cascadilla Creek which extended from the level of the creek to the level of the College of Agriculture campus. Fitz-bews were known to nest there, usually in *Crataegus,* for several years prior to 1955.

In two areas studied, only nests of fee-bee-o's were found, and no fitz-bews were known to occur. The first of these was in Michigan Hollow along the creek about five kilometers south of Danby. The altitude was 390 meters. A nest from the Inlet Valley, two kilometers south of West Danby at an elevation of 308 meters, was also included in this population. *Alnus incana rugosa* grew along the edge of the beaver pond at this locality in Michigan Hollow and spread into the moist depressions in adjacent fields. *Spiraea alba* formed extensive, low thickets. *Rubus* was common where there was no *Spiraea.* The West Danby area was next to a sedge swamp, bordered with *Alnus.*

TABLE 3

Summary of frequency of occurrence and average rating of cover of shrubs in 10- and 5-meter quadrats respectively—fee-bee-o's

	10-METER QUADRATS		5-METER QUADRATS	
	NO.	FREQUENCY (%)	NO.	AVERAGE RATING OF COVER
Michigan Hollow (n=5)				
Alnus incana rugosa	4	80	2	0.60
Cornus alba stolonifera	1	20	1	0.40
Pinus strobus	1	20	1	0.40
Populus tremuloides	1	20	1	0.40
Prunus virginiana	2	40	2	0.40
Pyrus malus	1	20	1	0.20
Rhus typhina	1	20	1	0.20
Ribes hirtellum	1	20	1	0.20
Rubus allegheniensis	1	20	1	0.40
idaeus	3	60	3	2.20
Salix bebbiana	1	20	1	0.40
discolor	1	20	1	0.40
Spiraea alba	2	40	2	1.40
Horse Pasture (n=3)				
Cornus racemosa	2	67	2	2.33
Crataegus dodgei	1	33	1	0.67
(*?filipes*)	2	67	2	1.67
Lonicera tatarica	1	33	1	0.33
Prunus serotina	1	33	1	0.67
Pyrus malus	1	33	1	0.33
Rosa cinnamomea	1	33	1	0.33
Ulmus americana	1	33	0	0.00

The slopes of the Horse Pasture, where the second population of fee-bee-o's occurred, was moderately drained and was dominated by *Crataegus, Cornus* and *Lonicera.* The area did not seem to be very different from the slope above Cascadilla Creek, 1.5 kilometers to the southeast, where the fitz-bews formerly occurred.

Data from quadrats in fee-bee-o populations are summarized in table 3; appendix table 3 includes information for individual quadrats.

The two general areas of study which remain were both occupied by mixed populations of fitz-bews and fee-bee-o's. The data from these areas are summarized in table 4, the data from individual quadrats in appendix table 4.

The Cornell East Hill Airport area has many abandoned fields, now covered with *Daucus carota, Hieracium* sp., grasses and other herbs.

TABLE 4

Summary of frequency of occurrence and average rating of cover of shrubs in 10- and 5-meter quadrats respectively—mixed populations of alder flycatchers

	10-METER QUADRATS				5-METER QUADRATS			
	FITZ-BEW		FEE-BEE-O		FITZ-BEW		FEE-BEE-O	
	NO.	PERCENTAGE	NO.	PERCENTAGE	NO.	AVERAGE RATING OF COVER	NO.	AVERAGE RATING OF COVER
East Hill Airport fitz-bew (n=10) fee-bee-o (n=7)								
Cornus racemosa	5	50.0	4	57.2	5	0.90	3	1.28
Crataegus dodgei	0	0.0	1	14.3	0	0.00	1	0.43
Fraxinus pennsylvanica	1	10.0	1	14.3	1	0.20	1	0.14
Lonicera tatarica	1	10.0	0	0.0	1	0.10	0	0.00
Pinus strobus	0	0.0	1	14.3	0	0.00	1	0.43
Prunus serotina	1	10.0	0	0.0	1	0.10	0	0.00
virginiana	1	10.0	2	28.5	1	0.10	2	0.43
Rubus idaeus	1	10.0	2	28.5	1	0.20	1	0.29
Salix bebbiana	0	0.0	2	28.5	0	0.00	2	0.71
fragilis	0	0.0	2	28.5	0	0.00	2	0.57
Sambucus canadensis	1	10.0	0	0.0	1	0.10	0	0.00
Ulmus americana	3	30.0	1	14.3	3	0.60	1	0.14
Viburnum dentatum	10	100.0	5	71.4	10	2.80	5	1.57
lentago	0	0.0	2	28.5	0	0.00	2	0.57
Etna Substation fitz-bew (n=1) fee-bee-o (n=2)								
Cornus racemosa	1		2		1	2.00	2	1.50
Crataegus (?punctata)	1		1		1	2.00	1	0.50
Pyrus malus	1		1		1	2.00	1	1.00
Rubus occidentalis	0		1		0	0.00	1	1.50
Salix bebbiana	1		0		1	1.00	0	0.00
discolor	1		0		1	2.00	0	0.00
sericea	1		0		1	2.00	0	0.00
Ulmus americana	1		0		1	1.00	0	0.00

The fields are divided by hedgerows, primarily of *Viburnum dentatum* and *Cornus racemosa*. Several artificial marshes have been constructed in the area, and alder flycatchers may be found near them as well as near natural moist depressions or small streams. At Sapsucker Woods, south of the airport, fee-bee-o's were found nesting below the dike and also in a young *Pinus strobus* plantation. These birds are also included with the airport population.

In 1956 a colony of fitz-bews settled near the airport terminal building in a spot entirely surrounded by runways. Prior to this, fitz-bews were known only from the northeast sector. These were some of

TABLE 5

Summary of frequency of occurrence and average rating of cover of shrubs in 10- and 5-meter quadrats respectively—by song-type

	10-METER QUADRATS				5-METER QUADRATS			
	FITZ-BEW (N=38)		FEE-BEE-O (N=17)		FITZ-BEW		FEE-BEE-O	
	NO.	PERCENTAGE	NO.	PERCENTAGE	NO.	AVERAGE RATING OF COVER	NO.	AVERAGE RATING OF COVER
Alnus incana rugosa	0	0.0	4	23.5	0	0.00	2	0.18
Cephalanthus occidentalis	1	2.6	0	0.0	1	0.11	0	0.00
Cornus alba	14	36.8	1	5.9	11	0.74	1	0.12
amomum	1	2.6	0	0.0	1	0.53	0	0.00
racemosa	12	31.5	8	47.1	11	0.66	7	1.12
Crataegus dodgei	0	0.0	2	11.8	0	0.00	2	0.30
(*?filipes*)	2	5.3	2	11.8	2	0.13	2	0.30
(*?punctata*)	1	2.6	1	5.9	1	0.05	1	0.06
Fraxinus pennsylvanica	1	2.6	1	5.9	1	0.05	1	0.06
Lonicera tatarica	1	2.6	1	5.9	1	0.03	1	0.06
Pinus strobus	0	0.0	2	11.8	0	0.00	2	0.30
Populus tremuloides	0	0.0	1	5.9	0	0.00	1	0.12
Prunus serotina	1	2.6	1	5.9	1	0.03	1	0.12
virginiana	9	23.7	5	29.6	3	0.11	4	0.30
Pyrus malus	3	7.9	3	17.7	1	0.05	3	0.24
Rhus typhina	7	18.4	1	5.9	3	0.16	1	0.06
Ribes hirtellum	0	0.0	1	5.9	0	0.00	1	0.06
Rosa cinnamomea	0	0.0	1	5.9	0	0.00	1	0.06
Rubus allegheniensis	1	2.6	1	5.9	1	0.11	1	0.12
idaeus	12	31.6	5	29.6	8	0.45	4	0.76
occidentalis	2	5.3	1	5.9	2	0.11	1	0.17
Salix bebbiana	1	2.6	3	17.7	0	0.00	3	0.41
discolor	2	5.3	1	5.9	2	0.13	1	0.12
fragilis	4	10.5	2	11.8	0	0.00	2	0.24
nigra	6	15.8	0	0.0	5	0.45	0	0.00
rigida	1	2.6	0	0.0	1	0.05	0	0.00
sericea	1	2.6	0	0.0	1	0.05	0	0.00
Sambucus canadensis	15	39.4	0	0.0	15	1.10	0	0.00
Spiraea alba	0	0.0	2	11.8	0	0.00	2	0.41
Ulmus americana	5	13.2	2	11.8	4	0.18	1	0.06
Viburnum dentatum	12	28.9	5	29.6	10	0.74	5	0.65
lentago	0	0.0	2	11.8	0	0.00	2	0.24
Vitis vulpina	4	10.5	0	0.0	2	0.11	0	0.00

the instances where birds of the opposite song-type were known to occur within hearing range of one another throughout the breeding season.

The Etna Substation area was a fallow field, moderately to poorly drained, grown up with *Salix* sp. in the wetter, and *Crataegus* and *Pyrus* in the drier parts. Much of the poorly drained area was swampy, with a compact growth of sedges, sensitive fern and some cattails.

Table 5 shows the frequency of occurrence for all shrubs found in any of the 38 fitz-bew and 17 fee-bee-o quadrats analyzed. The species found most commonly in fee-bee-o quadrats were *Cornus racemosa,* 47.1 percent; *Rubus idaeus, Prunus virginiana,* and *Viburnum dentatum,* 29.6 percent each and *Alnus incana rugosa,* 23.5 percent. In fitz-bew quadrats the most common were *Sambucus canadensis,* 39.4 percent; *Cornus alba,* 36.8 percent; *Cornus racemosa, Rubus idaeus* and *Viburnum dentatum,* 31.6 percent, and *Prunus virginiana,* 23.7 percent.

Some species which occurred in quadrats of both song-types showed contrasts in frequency between them. *Cornus racemosa, Salix bebbiana* and the genus *Crataegus* were more common in fee-bee-o quadrats. *Cornus alba, Sambucus canadensis* and *Salix nigra* were more common in those of fitz-bews.

Certain other species occurred only in the quadrats of birds of one song-type. The following were found only in fitz-bew quadrats: *Sambucus canadensis,* 17 quadrats; *Vitis vulpina,* 4; *Cephalanthus occidentalis, Cornus amomum, Salix nigra, S. rigida* and *S. sericea,* 1 each. These were found only in fee-bee-o quadrats: *Alnus incana rugosa,* 4; *Pinus strobus, Spiraea alba,* and *Viburnum lentago,* 2 each; *Populus tremuloides, Ribes hirtellum* and *Rosa cinnamomea,* 1 each.

In the five-meter fitz-bew quadrats, *Cornus alba, Salix nigra* and *Sambucus canadensis* had higher average ratings as cover and in the five-meter fee-bee-o quadrats *Cornus racemosa, Crataegus dodgei, Pinus strobus, Rubus idaeus, Salix bebbiana* and *Spiraea alba* had higher average ratings.

In all of the quadrats, 98 species of herbs were identified. Eight species were found only in fee-bee-o quadrats, and these occurred only in one quadrat each. Of the 28 species found only in fitz-bew quadrats, *Asclepias syriaca* occurred in 8, *Pastinaca sativa* in 7, *Carex riparia* and *Convolvulus sepium* in 4 each, and the remaining species in 3 or less. Of the 62 species found in quadrats around nests of both song-types, 7 species occurred more than twice as often proportionately in fee-bee-o as in fitz-bew quadrats: *Cerastium vulgatum, Anthoxanthum odoratum, Hieracium pratense, Linnaria vulgaris, Onoclea sensibilis,*

Plantago lanceolata and *Potentilla canadensis*. The following 7 species occurred more than twice as commonly in fitz-bew as in fee-bee-o quadrats: *Agrostis alba, Arctium lappa, Barbarea vulgaris, Carex vulpinoidea, Impatiens biflora, Inula helenium* and *Urtica procera.*

SITE OF THE NEST

The site of the nest is perhaps the most tangible expression of the response of an alder flycatcher to the vegetation in its territory. Species of plants commonly used for nesting were listed in many of the papers describing habitat cited on page 28.

Near Ithaca, fitz-bews nested in bushes which were often two meters or more high. Fee-bee-o's tended to build their nests in lower bushes near large ones. These nests, because of their position, were usually harder to find.

Table 6 is a summary, by song-types, of the number of quadrats in which each species of shrub occurred and the number of nests built in that shrub, and appendix table 6 gives the same information for each population. *Viburnum dentatum* and *Sambucus canadensis* were the most common nesting sites of fitz-bews. *Rubus, Cornus* and *Salix* were used less frequently.

Further comparisons show the responses of individual birds to potential nesting sites where two or more suitable species, used by individuals of the same song-type in other territories, were directly

TABLE 6

Occurrence in 10-meter quadrats and use as nesting sites of shrubs—by song-types

	FITZ-BEW			FEE-BEE-O		
	NO. NESTS	NO. QUADRATS	PERCENTAGE	NO. NESTS	NO. QUADRATS	PERCENTAGE
Cornus alba	5	14	35.7	1	1	100.0
Cornus racemosa	3	12	25.0	4	8	50.0
Crataegus dodgei				2	2	100.0
Crataegus (?filipes)	2	2	100.0	0	2	0.0
Crataegus (?punctata)	1	1	100.0	0	1	0.0
Rosa cinnamomea				1	1	100.0
Rubus allegheniensis	1	1	100.0	0	1	0.0
Rubus idaeus	1	12	8.3	2	5	40.0
Rubus occidentalis	0	2	0.0	1	1	100.0
Salix bebbiana	0	1	0.0	1	3	33.3
Salix fragilis	0	4	0.0	1	2	50.0
Salix nigra	2	6	33.3			
Sambucus canadensis	13	15	86.7			
Spiraea alba				2	2	100.0
Viburnum dentatum	10	11	90.9	1	5	20.0
Viburnum lentago				1	2	50.0
Total	38			17		

available. Table 7*a* is a summary of the number of times each particular species of shrub was used as a nesting site by fitz-bews when each of the other genera listed was also present. The analysis is based on genera of shrubs, since nests were found in several species of some, and the number of comparisons would be much smaller for individual species. Both the 5- and 10-meter quadrats were included in the comparison. Each time a quadrat had two or more of the genera listed, a comparison was possible. In those quadrats where three or more of

TABLE 7

Comparison of shrubs used as the site of nest with other genera of shrubs available in 10-meter quadrats

A. FITZ-BEWS

	OTHER GENERA IN 10-METER QUADRATS					
SITE OF NEST	SAMBUCUS	CORNUS	SALIX	RUBUS	VIBURNUM	TOTAL
Sambucus		5	5	8		18
Cornus			5	3	1	9
Salix		1				1
Rubus	1	2				3
Viburnum	1	5		1		7
Crataegus		3	1			4
Total No. of Nests	2	16	11	12	1	42

B. FEE-BEE-O'S

	OTHER GENERA IN 10-METER QUADRATS								
SITE OF NEST	CORNUS	CRATAEGUS	RUBUS	SALIX	VIBURNUM	PRUNUS	PYRUS	ALNUS	TOTAL
Cornus		1	1	1	1	2	1	1	8
Crataegus				1	1	1	1		4
Rosa	1	1							2
Rubus						1			1
Salix			1		1				2
Spiraea			2			1	1	1	5
Viburnum	1					1			2
Total No. of Nests	2	2	4	2	3	6	3	2	24

the genera listed were present, a comparison was made between the one in which the nest was built and each of the others. Of the 38 quadrats around the nests of fitz-bews, 8 had only one of the genera present and could not be used. The remaining 30 quadrats afforded 42 comparisons. The rank of use as a nesting shrub for each of the genera follows:

1. *Sambucus, Viburnum* or *Crataegus*
2. *Cornus*
3. *Rubus*
4. *Salix*

The genera of first rank were almost always used as the site of the nest in those quadrats in which they occurred. Among the other genera

listed, the most common was used as the site for the nest. Additional evidence from a larger number of quadrats will help to develop a more definite pattern.

While the 38 fitz-bew nests were located in 8 species from 6 genera, the 17 fee-bee-o nests were found in 11 species from 7 genera.

Table *7b* is an analysis of the nesting sites for fee-bee-o's similar to Table *7a* for fitz-bews. In addition, the genera *Prunus, Pyrus* and *Alnus* were included, since these genera were mentioned in the literature as having been used for nesting sites, and several comparisons were possible in this study. Fifteen of the 17 quadrats yielded 25 comparisons. However, these comparisons seemed to be distributed without pattern. It will be necessary to study many more quadrats around nests of this song-type to determine whether any pattern will appear.

At the East Hill Airport, where a comparison of the two types in close proximity was possible, the fitz-bew nests were always found in *Viburnum dentatum,* but this species was used only once by a fee-bee-o. A direct comparison of the general ecology of the two song-types was illustrated by fitz-bew nest 56-14 and fee-bee-o nest 55-14. Both nests were found in *Viburnum dentatum,* about 20 meters apart from one another. Only one song-type was present each year, although the territories of each year included the site of both nests. The fitz-bew nest was just in from the north edge of a hedgerow, which had begun to spread into the field to the north. The fee-bee-o nest was found in a low shrub about three meters north of the hedgerow.

The fee-bee-o's in any population appeared to be less restrictive in the use of particular shrubs for nesting than the fitz-bews.

HEIGHT OF NEST ABOVE GROUND

Several papers give the range and mean of heights for nest. For fitz-bews near Ann Arbor, Mich., Berger and Hofslund (1950) reported a range of 41-63 inches (104.5-160.0 cm.) and a mean of 49.5 inches (125.7 cm.) for a series of 17 nests. Three additional nests ranged from 7 to 10 feet (2.23-3.05 meters). Meanley (1952) gave a mean of 7.5 feet (2.29 meters) from the ground for 15 nests of presumed fitz-bews from Arkansas. Campbell (1936), describing a colony of flycatchers from Lucas County, Ohio, specifically listed 4 nests between 3.5 and 7 feet (1.17 and 2.14 meters) above the ground.

For nests of the fee-bee-o type, Mousley (1931) listed 3 nests from Quebec, all found in *Spiraea,* at heights between 2 feet and 2 feet 6 inches (0.61-0.76 meters) above the ground, and Farley (1901) described one nest at 43.5 inches (1.07 meters).

Table 8 shows the range and average height of nests for each song-type according to the species of shrub in which the nest was built. The range for the 38 fitz-bew nests was 45.5 to 269 cm., with a mean height of 141.2 cm. above the ground. Fee-bee-o nests ranged from 38 to 83.5 cm. and had a mean height of 58 cm. Aside from 2 fitz-bew nests, one each at 45.5 and 76 cm., all fitz-bew nests were higher above the ground than all those of the fee-bee-o's.

The comparison of the heights of the nests built by both song-types in a particular species of shrub shows a consistently higher mean for the fitz-bew nests, and only one case of overlap of range between the two.

TABLE 8

Height of nest above ground (in centimeters)

	FITZ-BEW			FEE-BEE-O		
Species of plants used by both song-types	NO.	RANGE	AVER-AGE	NO.	RANGE	AVER-AGE
Cornus alba	5	91.5–163	132.6	1	38	38
Cornus racemosa	3	120–168	138.8	4	46–61	51.2
Rubus idaeus	1	119	119	2	61	61
Viburnum dentatum	10	45.5–160	107	1	83.5	83.5
Species of plants used by one type only						
Crataegus dodgei				2	46–58.5	52.3
(*?filipes*)	2	117–137	127			
(*?punctata*)	1	124	124			
Rosa cinnamomea				1	46	46
Rubus allegheniensis	1	183	183			
Rubus occidentalis				1	51	51
Salix bebbiana				1	76	76
Salix fragilis				1	61	61
Salix nigra	2	122–269	164			
Sambucus canadensis	13	76–244	164			
Spiraea alba				2	46–56	51
Viburnum lentago				1	76	76
Overall total	38	45.5–269	141.2	17	38–83.5	58
Standard deviation			44.48			12.25
Standard error of mean			7.27			2.97

STRUCTURE OF NEST

Two types of nests have been recognized in the Ithaca area, and these, in general, compare directly to previous descriptions of nests and their variation. The first of these types resembles the nest of a goldfinch (*Spinus tristis*) or yellow warbler (*Dendroica petechia*).* This is the

* Nests of this sort are illustrated by Campbell (1931) and are described by Meanley (1952) and Hanshaw (1876).

compact nest of the fitz-bew which rarely has streamers. The second type, a coarser, more loosely constructed nest, resembles the nest of a song sparrow (*Melospiza melodia*) or indigo bunting (*Passerina cyanea*). This is the nest of the fee-bee-o which regularly has streamers, and often appears "untidy."*

Both song-types show variation in the structure of the nest. A factor which seems to have much influence on the final appearance of the nest, aside from the materials used, is whether the nest is constructed on a horizontal branch, such as a *Rubus* cane, or in the upright fork of a shrub, such as *Viburnum dentatum.*

The fitz-bew nest may be described as having a grayish appearance, the result of the material used. An example of a fitz-bew nest is shown in figure 5. Nests found in the Ithaca area were usually constructed at or near the outside perimeter of the nest shrub in an upright fork. If the cover of leaves was not very dense, the nest was frequently built in the interior of the shrub. The nest was occasionally found on a horizontal limb where it was sometimes supported, in addition, by other independent upright branches.

Nests built in vertical crotches occasionally had silky streamers hanging from the bottom of the nest.

The fitz-bew nests were regularly lined with fine grasses. *Poa compressa* was identified in one nest. Several nests contained *Daucus carota,* and several contained *Arabidopsis,* although the only Cruciferae present in the 5-meter quadrats were *Barbarea vulgaris* and *Brassica nigra. Arabidopsis* is common in some locations in the Inlet Valley.

The shredded bark of what appeared to be the common and swamp milkweeds (*Asclepias syriaca* and *A. incarnata*) was found in the nests. *Anthoxanthum odoratum* was identified in one nest. Those grasses used on the outside, though not identifiable, were coarser than those used for the lining.

Cottony or silky material was utilized in each of the fitz-bew nests. The fruit of *Typha latifolia* was identified in about 60 percent of the nests, the silky material of *Populus deltoides* and *Salix* sp. was identified in about 40 percent and silk from *Aselepias* in about 20 percent. The cottony material was often felted together, probably the result of weathering.

Feathers were found in at least eight of the fitz-bew nests. Feathers of the pheasant (*P. colchicus*) were found in 3 nests; those of the

* Nests of this sort are illustrated in Bent (1942, pl. 26), and are described by Mousley (1931) and Purdie (1876). Purdie was the first to comment on the differences in structure of the nest. Aldrich (1953) and Snyder (1953) reiterated the contrast, but King (1955) stated that they were "normal structural variants within the population of *Empidonax traillii*" from the Palouse Prairie of eastern Washington.

Figure 5. Nest of fitz-bew alder flycatcher (Photo by R. B. Fischer)

Figure 6. Nest of fee-bee-o alder flycatcher (Photo by R. B. Fischer)

American bittern (*Botaurus americana*) in 2. One nest each contained feathers from the mallard (*Anas platyrhynchos*), pigeon (*Columba livia*), Baltimore oriole (*Icterus galbula*) and yellowthroat (*Geothlypis trichas*). Other feathers could not be identified. One nest contained feathers of the American bittern, ring-necked pheasant, mallard and pigeon. The feathers were usually toward the top of the cup, or were woven into the rim of the nest.

A typical fee-bee-o nest is shown in figure 6. The lining of the nests of fee-bee-o's observed was of wiry grass and grass slightly coarser than that used in fitz-bew nests. In two nests, needles of *Pinus strobus* were found. Culms from *Poa pratensis* and *P. compressa* were taken from one nest. There is no indication of feathers in any of the fee-bee-o nests.

The outside of the nest, made of coarse grass, usually had many short projections of material, giving an unkempt and bulky appearance. Streamers frequently hung downward either from the rim or the bottom to well below the bulk of the nest. Among the specific materials identified were moss, pieces of *Typha* leaves, leaves of grass up to 5 mm. broad, rootlets, bark, twiglets and bud scales of *Salix*.

The cottony or silky type of material used regularly by fitz-bews occurred occasionally, but only in very small amounts, in fee-bee-o nests. One case of *Typha* fruit was noted and silky material like small cocoons was also found.

The following measurements were obtained from a series of complete nests collected in 1955 and 1956, 12 of them from fitz-bews and 9 from fee-bee-o's:

TABLE 9

Dimensions of nests, by song-type

	FITZ-BEW		FEE-BEE-O	
	RANGE	MEAN	RANGE	MEAN
Inside diameter	45–57 mm.	51 mm.	42–57 mm.	50 mm.
Inside depth	30–37	36	30–36 (one 50)	36
Outside diameter	70–90 mm.	75 mm.	75–90 mm.	79 mm.
Outside depth	50–80	65	60–90	73

The table does not show any great difference in size between the two song-types. However, only the body of the nest was measured, exclusive of streamers.*

Two nests were collected at Lew Beach, Sullivan County, N. Y., by Dr. Richard B. Fischer, one each in 1953 and 1954. Both nests were built less than one meter from the ground in clumps of *Spiraea*

* The inside depth and diameter of the fitz-bews' nests compare favorably with the measurements of Campbell (1931) and Berger and Hofslund (1950).

alba near one another. The 1953 nest most resembles the fee-bee-o type as described from Ithaca, although Dr. Fischer heard birds of the fitz-bew song-type nearby. In contrast, the other nest has a grayish appearance and seems to be within the range of the fitz-bew nests from Ithaca. Contrasts between these two nests and those found in Ithaca indicate the possibility that variations in structure found in Ithaca are not expressive of the total range for each song-type.

COLOR AND SIZE OF EGGS

A series of 30 measurements was made on eggs of fitz-bews, at least one egg being measured from each of 11 nests. Ten eggs of fee-bee-o's were measured, representing four nests. A tabulation of the results may be found in table 10. The enumeration of data may be found in appendix table 6.

TABLE 10

Summary of data on egg size

	FITZ-BEW	FEE-BEE-O	
Sample size	30	10	
Length in mm.			
Extremes	17.4–19.17	17.8–19.8	
Mean	17.91	18.51	d=0.60*
Standard deviation	0.547	0.84	
Standard error of mean	0.0316	0.2656	
Diameter in mm.			
Extremes	12.9–14.0	13.6–14.6	
Mean	13.7	14.06	d=0.36**
Standard deviation	0.287	0.334	
Standard error of mean	0.0523	0.1064	

* Significant (5 percent level) difference.
** Highly significant (1 percent level) difference.

Egg color is not a sharply defined character. Fee-bee-o's always had whitish eggs. These eggs usually had small, contrasting spots of cinnamon brown at the large end, but these spots were sometimes surrounded by larger, more diffuse areas of color. Fitz-bew eggs were regularly buff-colored, usually with the diffuse areas of color. Some fitz-bew eggs were whitish and had only dark, intensely colored spots near the large end. The four eggs collected from nest 55-8, after the nest had been abandoned, ranged from buff or pinkish brown ground color with many large, diffuse spots to whitish with sharply defined dark brown spots. One of the eggs was intermediate in ground color and markings.

Kendeigh (1956) wrote that in the house wren (*Troglodytes aedon*) the following factors influenced egg size; place in sequence of laying, the first egg in the clutch being smaller and more variable on the

average; and the age of the female, first year birds laying smaller eggs. He found that the number of eggs in the clutch did not influence egg size and that the eggs laid by one female varied less than the average characteristics of clutches from different females. He also hypothesized that the energy resources of the bird, prior to egg laying, influence the physical characteristics of the eggs.

While no data comparable to that for wrens is available for alder flycatchers, these factors should be considered as possibly contributing to the slight, but significant, difference between eggs of the song-types. These factors, being essentially environmental rather than genetic, can disguise the estimate of genetic variability and result in erroneous comparisons.

The fitz-bews started laying eggs earlier than fee-bee-o's. Since all the eggs were measured on the same day, at the height of fitz-bew nesting, more of these clutches were available and complete. Fee-bee-o's had larger eggs, though if the situation is parallel to that of house wrens, the large extremes may not have been attained. While the general appearance and size of the eggs in a clutch seemed to be less variable than the average condition of several clutches, especially in fitz-bews, the one clutch mentioned showed extreme variation. The age of the female and the diet and energy resources, the latter influenced by the ecological differences present between the two types, might also be important factors. Their influence, however, cannot be estimated.

NESTING TIME

Alder flycatchers observed in the Ithaca area in 1955 laid clutches averaging between 3 and 4 eggs. The eggs were usually laid on consecutive days. The incubation period, as measured from the day the last egg was laid until the day the last egg hatched, was obtained for five nests. Three fitz-bews had 12-day incubation periods; one, 13. One fee-bee-o clutch took 14 days to hatch.

In order to compare peak periods of nesting activity for the two song types, a point in the nesting cycle—the date on which the third egg was laid—was noted for 15 fitz-bew and 5 fee-bee-o nests. For the limited sample, the period when most eggs were at this stage ranged from June 16 to 24 for fitz-bews and June 28 to July 3 for fee-bee-o's. The last fitz-bew laid its third egg on July 14, but its earlier nest was destroyed between July 5 and 12.

The data suggest that: (1) fitz-bews start to nest earlier than fee-bee-o's, whose nesting period is within that of the fitz-bews; (2) the period of greatest nesting activity may be 1½ to 2 weeks earlier for

fitz-bews than for fee-bee-o's; (3) birds whose nests have been destroyed may renest as late as mid-July, and (4) the differences in the period of greatest nesting activity may act as a reinforcing isolating mechanism.

MORPHOLOGY

The object of this phase of the study was to discover the extent of morphological differences between the two song-types and subsequently to make morphological comparisons between the song-types and recognized subspecies. Comparisons were made on the length of chord of wing, tail, tarsus and bill, and on color.

CHORD OF WING

The statistical data on this and the other three characters measured for length are presented in table 11; the raw data in appendix table 1.

The means and standard deviation for fitz-bews and fee-bee-o's are 70.50 ± 1.503 mm. and 71.46 ± 1.906 mm. respectively. The difference between the means is 0.96 mm. The pooled variance, with 65 d. f., is 0.4266 mm. The "t" value obtained was 2.25, a number significant at the 0.05 but not at the 0.01 level. The coefficient of variability for fitz-bews and fee-bee-o's is 2.13 and 2.67 respectively.

The only published account with measurements and statistical analyses to which these data can be directly compared is that of Snyder (1953). Snyder stated that the differences between his northern and southern populations are not significant for any character he measured. The sums of squares for his measurements of chord of wing and length of tail were estimated by calculating from his standard error. The "t" test on these estimates supports Snyder's observation.

TABLE 11

Summary of morphological measurements (in millimeters)

	MEAN	STANDARD DEVIATION	ST. ERROR MEAN	C. V. %	RANGE	SAMPLE SIZE
Fee-bee-o						
Males						
Wing chord	71.46	1.906	0.318	2.67	68.5–75.0	36
Tail	58.00	1.426	0.252	2.46	55.0–61.0	32
Tarsus	16.55	0.500	0.083	3.02	15.25–17.75	36
Bill	8.56	0.496	0.083	5.79	7.60–9.60	36
Fitz-bew						
Males						
Wing chord	70.50	1.503	0.266	2.13	67.0–73.0	32
Tail	58.06	1.323	0.242	2.28	56.0–60.9	30
Tarsus	16.18	0.394	0.070	2.44	15.00–17.25	32
Bill	8.99	0.431	0.077	5.00	8.00–10.00	31

Fee-bee-o's have about the same range as Snyder's northern population, and the means were not significantly different. The series of fitz-bews had an observed range which was about one millimeter shorter than Snyder's southern series, but the means, again, were not significantly different.

Within the limitations of sampling error introduced by two different workers and this author's estimates of Snyder's sums of squares (which contain compounded error due to the rounding of numbers) the information on the length of the chord of the wing suggests that reinforcement might be taking place in an area of sympatry.

LENGTH OF TAIL

The difference between the length of tail in the series of fitz-bews and fee-bee-o's was not significant. For fitz-bew males the tail length was 58.06 ± 1.323 mm., for fee-bee-o's 58.00 ± 1.426 mm.

A comparison of these measurements shows that the fitz-bew extremes are slightly longer and the fee-bee-o extremes slightly shorter than Snyder's observations on his series. The difference between the mean of Snyder's northern series and that of the fee-bee-o's was not significant, but the difference between the means of his southern series and the series of fitz-bews was highly significant. The difference between the series of northern and southern alder flycatchers studied by Snyder was not significant.

LENGTH OF TARSUS

A "t" test indicated that the difference between the means of 16.18 mm. for the series of fitz-bews and 16.55 mm. for the fee-bee-o's was highly significant, but no published data contain enough information to make further statistical comparisons possible.

LENGTH OF BILL

As seen in table 11, the difference between the means was 0.43 mm. The "t" value obtained indicated that the fitz-bews and fee-bee-o's were highly significantly different with respect to this character.

COLOR

In each of the series the range of color showed overlap with the other, as did the quantitative measurements previously discussed, and therefore only average differences can be pointed out.

Only the back color was compared, since other differences of color seemed slight or nonexistent.

The series of *E. t. campestris* which was assembled may be described as pale-toned, and with a grayish cast; the series of *E. t. traillii* as dark-toned and greenish.

The series of known fitz-bews was intermediate in color between the two "type series." The individuals in the series ranged from almost as pale-toned as the type of *campestris* to almost as dark and greenish as the birds from New England. The two specimens from Nebraska compared very favorably with the type of *campestris* and were included in that series. The subspecies *E. t. campestris* clearly represents the fitz-bew song-type. It was hypothesized that the fitz-bews which have invaded New York along the lake plains and the Hudson River Valley would be derived from that segment of *campestris* from farther east, probably in Ohio. It was suspected that these birds would be darker because the environment in Ohio is more moist than in the prairies of North Dakota and Nebraska. A subsequent check of breeding specimens from Ohio confirmed this, and the specimens from Pelee Island, Ontario, compare favorably in color intensity of the back with the series from Ohio. The darkest of the fitz-bews were collected in the Buffalo and Ithaca areas. The population described as *E. t. campestris* by Aldrich (1951) probably exhibits a transition from light to dark, from west to east, as indicated by specimens of known fitz-bews as well as breeding birds.

The known series of fee-bee-o's were definitely different in dorsal color from the known fitz-bews collected, although they had much variation, and overlap with the fitz-bew series occurred with many individuals. The known series of fee-bee-o's were most similar to the New England series and to Audubon's type, the population represented by Aldrich's interpretation of *E. t. traillii*. The color of the known fee-bee-o's was as dark or slightly darker, on the average, than those of the New England series.

PROBLEMS OF NOMENCLATURE

The morphological comparison of the series of song-types with the type specimens indicated that if they were only considered good subspecies, then the fee-bee-o's would be *E. t. traillii* (Audubon) and the fitz-bews *E. t. campestris* Aldrich. However, if the two song-types were given specific rank, then the fee-bee-o would be *Empidonax traillii* (Audubon), probably with no subspecies.

The specific designation of the fitz-bew song-type cannot be definitely resolved on the basis of present data. One recording indicates that the fitz-bew type, or variation thereof, occurs at the University of Washington Biological Station at Friday Harbor, Wash. This locality

is within the range of *E. t. brewsteri* Oberholser (1918) as interpreted by Aldrich (1951). These birds are more brownish than *E. t. campestris,* and do not compare favorably in color with the known fitz-bews. Since *E. t. brewsteri* is the oldest available subspecific name, and there is some evidence that the fitz-bew occurs in the range of this subspecies, the fitz-bew would become *E. brewsteri.* However, specimens have not been collected by song-type to determine that such is the case.

From the recording and nest collected by Dr. Allen in Utah, it seems fairly certain that *E. t. adastus* Oberholser (1932) is of the fitz-bew type. Judging from its geographical range, *E. t. extimus* Phillips (1948) is probably also a fitz-bew. If and when the fitz-bew is recognized as a distinct species, and *E. t. brewsteri* is shown to be of this song-type, then the hypothetical *E. brewsteri* would probably have four subspecies: *brewsteri, adastus, extimus* and *campestris.*

SUMMARY AND CONCLUSIONS

As a result of the selective pressures of species recognition and predation, four trends are hypothesized for species which use sound instead of sight for species recognition and as a reproductive isolating mechanism: (1) a lack of sexual dimorphism, (2) protective coloration, (3) similar coloration among closely related species, with or without differences in proportion according to adaptation to particular environmental niches, and (4) distinctive songs, particularly for sympatric species. This study has applied the hypothesis to the genus *Empidonax,* especially to *E. traillii* (Audubon). The study was done primarily in central and western New York State, especially Ithaca, during the summers from 1953 to 1956 and covered behavioral, ecological and morphological characteristics. The results are summarized in table 12.

The two song-types of the alder flycatcher, referred to here as fee-bee-o and fitz-bew, previously have been shown to have distinct advertising songs, with no overlap of pattern, while some sounds associated with hostile behavior were similar in both.

The general pattern of hostile behavior for both song-types was essentially the same. The variations in response were affected by two variables: the intensity of the attack and escape drives relative to one another, and the actual strength of the hostile drive itself. Reactions to the playback of recorded songs in the field showed that each of the two song-types could recognize the difference between the patterns of the songs and that each one reacted to playback of its own song as

Table 12

Summary of characters discussed—by song-type

CHARACTER	FEE-BEE-O	FITZ-BEW
General reaction to own song	positive	positive
General reaction to opposite song	negative	negative
General reaction to song of other *Empidonax* sp.	negative	negative
Geographical range	Canada, NE. United States	United States, especially west of Appalachian Mountains
Size of territory	0.013–0.030 sq. km.	0.011–0.018 sq. km.
Most common shrubs in 10-meter quadrats	*Cornus racemosa* *Rubus idaeus* *Viburnum dentatum* *Alnus incana*	*Cornus alba, racemosa* *Rubus idaeus* *Viburnum dentatum* *Sambucus canadensis*
Shrubs more common in quadrats of one than those of the other	*Alnus incana* *Cornus racemosa* *Spiraea alba* *Salix bebbiana* *Viburnum lentago* *Crataegus* sp.	*Cornus alba* *Sambucus canadensis* *Salix nigra*
Most common site of nest	no particular trend	*Viburnum dentatum* *Sambucus canadensis*
Height of nest above ground	38–82.5 cm. (mean 58.0 cm.)	45.5–269 cm. (mean 141.2 cm.)
Structure of nest	coarse, loose, similar to that of song sparrow	compact, cottony, similar to that of yellow warbler
Color of eggs	whitish with sharply defined dark brown spots	buffy with more diffuse purplish brown spots
Mean size of eggs*	18.51 X 14.06 mm.	17.91 X 13.70 mm.
Morphology (means, males)		
Chord of wing*	71.46 mm	70.50 mm.
Length of tail	58.00 mm.	58.06 mm.
Length of tarsus**	16.55 mm.	16.18 mm.
Length of bill**	8.56 mm.	8.99 mm.
Color of back	dark, greenish	lighter, grayish
Subspecific designation	*E. t. traillii*	*E. t. campestris*

* Significant (5 percent level) difference.
** Highly significant (1 percent level) difference.

would have been expected for any conspecific territorial invader. It reacted weakly, if at all, to the playback of the other song-type or other *Empidonax* species. This indicated that in Ithaca, an area of sympatry, the song-types used advertising song for species recognition and were reproductively isolated.

The geographical range of the fee-bee-o song-type was found to be across Canada, from the Maritime Provinces and into Alaska, New England and the northeastern United States. The range of the fitz-bew lay in the United States, especially west of the Allegheny Mountains. The area of sympatry and interdigitation occurred from central New York westward across southern Ontario to Michigan and Wisconsin, and probably to southern British Columbia.

Differences in habitat were shown for the two song-types. The territories of fee-bee-o's were larger than those of fitz-bews. *Cornus racemosa, Rubus idaeus* and *Viburnum dentatum* were common in quadrats of both song-types. Fee-bee-o's often had *Alnus incana rugosa* in addition; fitz-bew quadrats, *Sambucus canadensis* and *Cornus alba.*

The site of the nest showed distinct variation between the two song-types. Fitz-bews built a large proportion of nests in *Sambucus* and *Viburnum;* fee-bee-o's showed no definite pattern toward the use of specific shrubs. Fitz-bews built their nests higher above the ground than fee-bee-o's, the means being highly significantly different.

Fitz-bews built compact nests, using cottony or silky material in addition to bark and grasses, which could be compared in general form to nests of yellow warblers or goldfinches. They usually appeared grayish. Fee-bee-o's built loosely woven nests of coarse grasses, which were generally brownish and were comparable in appearance to those of song sparrows or indigo buntings.

Fee-bee-o eggs were significantly longer than those of fitz-bews, and highly significantly broader. The eggs of fitz-bews showed a greater variation of color than eggs of fee-bee-o's. Fitz-bew eggs ranged from buff with diffuse brown splotches to whitish with dark, sharply defined spots, while eggs of fee-bee-o's compared more to the latter description. The main period of egg laying was slightly earlier for fitz-bews.

The interaction between the song-types near Ithaca indicates that the fitz-bews have invaded a fee-bee-o area; that the ultimate result will be a preponderance of fitz-bews, especially at the lower elevations, and that the fee-bee-o's probably will be found in fewer, smaller areas than previously, mostly at higher elevations.

The following morphological characters were found to be highly significantly different: length of tarsus greater in fee-bee-o's; length of bill greater in fitz-bews. The chord of the wing was significantly

longer in fee-bee-o's, though the measurement was less reliable. No significant difference was found in length of tail. Although there was some overlap among particular individuals, the series of fitz-bews was lighter and grayer than the series of fee-bee-o's, which tended to be greener. The significant morphological differences indicate that there is probably reproductive isolation between the two song-types.

The evidence indicates that the two song-types represent distinct species in the Ithaca area at least; that these two breed within hearing range of one another, and that although interbreeding is possible, it apparently does not occur. It is not known, however, whether this is true throughout the area of sympatry. At this time it seems best to leave the fee-bee-o's as *E. t. traillii* (Audubon) and the fitz-bews as *E. t. campestris* Aldrich, since further research is needed to determine the disposition of *E. t. brewsteri* and its interaction with the fee-bee-o's, *E. t. traillii* in the area of contact in British Columbia (probably); to show in how large an area of sympatry the two song-types remain distinct, and to determine definitely that *E. t. adastus* and *E. t. extimus* are of the fitz-bew song-type.

APPENDIX

Specific geographical locations of local populations studied

Dryden Lake: Lat. 42°27′45″ N., Long. 76°16′55″ W., Alt. 350 m. At outlet of Dryden Lake, between Tripp Road and NY 38, 3.4 km. SSE. of Dryden, Dryden Twp., Tompkins County. (Dryden Quad. USGS topo. map.)

East Ithaca: Lat. 42°26′ N., Long. 76°28′40″ W., Alt. 268 m. 0.8 km. E. of NY 79 (Catskill Pike) and 0.5 km. S. of Ellis Hollow Road (NY 393), SE. of Ithaca, Ithaca Twp., Tompkins County along an old railroad bed south of the transformer house. (Ithaca East Quad.)

Etna Substation: Lat. 42°28′20″ N., Long. 76°24′15″ W., Alt. 320 m., 2.1 km. SW. of Etna, Dryden Twp., Tompkins County, 0.3 km. N. of NY 13, between it and the railroad. (Ithaca East Quad.)

Fleming Meadows: Lat. 42°25′ N., Long. 76°31′55″ W., Alt. 131 m. W. of NY 34A at junction of NY 34 and NY 34A, 4 km. SW. of Ithaca, Ithaca Twp., Tompkins County. (Ithaca West Quad.)

Hog Hole: Lat. 42°26′50″ N., Long. 76°30′40″ W., Alt. 119 m. In region of loop of Lehigh Valley Railroad 1-1.5 km. S. of SW. corner of Cayuga Lake, W. of NY 89, S. of Ithaca Municipal Airport, Ithaca Twp., Tompkins County. (Ithaca West Quad.)

Horse Pasture: Lat. 42°27′20″ N., Long. 76°27′45″ W., Alt. 274 m. An amphitheater on the north side of Fall Creek, 0.7 km. E. of Forest Home, Ithaca Twp., Tompkins County. (Ithaca East Quad.)

Inlet Valley: Lat. 42°17′30″ N., Long. 76°31′ W., Alt. 305 m. A specific locality in the whole "Inlet Valley," 3 km. SSE. of West Danby, 0.3 km. E. of NY 34 and 1.5 km. N. of Headwaters Swamp, Danby Twp., Tompkins County. (West Danby Quad.)

Ithaca-East Hill Airport: Lat. 41°40′ N., Long. 76°28′ W., Alt. 320 m. The region between Warren Road and Townline Road (now Sapsucker Woods Road) about 6 km. NE. of Ithaca, in Lansing Twp., Tompkins County. (Ithaca East Quad.)

Michigan Hollow Beaver Pond: Lat. 42°19′5″ N., Long. 76°28′40″ W., Alt. 393 m. 3.9 km. S. of Danby on Michigan Hollow Road on both sides of southernmost beaver dam, Danby Twp., Tompkins County. (Willseyville Quad.)

North Spencer Marsh: Lat. 42°15′50″ N., Long. 76°30′20″ W., Alt. 314 m. 0.7 km. NNE. of North Spencer, E. of US 34, N. of junction with Michigan Hollow Road in Spencer Twp., Tioga County. (West Danby Quad.)

Sapsucker Woods: Lat. 42°28′30″ N., Long. 76°26′55″ W., Alt. 332 m. 1 km. N. of Warren Road, 5.5 km. NE. of Ithaca in Dryden Twp., Tompkins County. (Ithaca East Quad.)

Appendix Table 1

Measurements of morphological characters—Fitz-bew males

CATALOG NO.	CHORD OF WING (mm.)	LENGTH OF TAIL (mm.)	LENGTH OF TARSUS (mm.)	LENGTH OF BILL (mm.)	DATE COLLECTED	LOCATION
RCS 55–3	72.5	59.0	15.90	9.15	6/15/55	Slaterville†
5	71.5	60.5	16.20	9.40	6/15/55	Dryden
8	70.0	58.2	16.40	9.60	7/28/55	Ithaca (Larch M.*)
9	68.0	56.7	15.65	9.00	7/28/55	Ithaca (Larch M.*)
CU 13041	72.0	60.0	16.00	8.50	6/21/42	West Dryden
21057	70.5	56.5	16.00	8.45	7/28/55	Ithaca (Larch M.*)
21060	70.5	57.7	16.05	8.80	7/28/55	Ithaca (Larch M.*)
NYSM 16986	73.0	60.9	16.40	9.30	7/8/54	Hilton Beach
Cleve 13444	72.5	56.0	16.80	8.95	6/7/31	W. Chautauqua Co.
13445	71.5	—	16.40	9.00	6/7/31	W. Chautauqua Co.
ROMZ 77599	69.5	56.5	16.00	9.00	6/7/50	Pelee Island, Ont.
77600	70.0	57.0	16.50	8.00	6/14/50	Pelee Island, Ont.
77602	69.5	56.9	16.50	—	7/27/50	Pelee Island, Ont.
RCS 56– 3	71.0	58.8	16.10	9.40	5/25/56	Ulster Co.
25	69.5	57.7	16.10	8.80	6/12/56	Ithaca (Hog Hole)
26	67.0	56.8	15.90	8.90	6/12/56	Ithaca (Hog Hole)
31	68.5	59.0	16.65	8.60	6/16/56	Ithaca (Compton Rd.)
34	70.5	59.5	15.60	9.20	6/18/56	Dryden Twp.
35	68.0	56.7	15.20	8.75	6/21/56	Erie Co.
36	70.5	—	16.40	9.05	6/21/56	Erie Co.
37	71.5	57.5	15.90	9.00	6/21/56	Erie Co.
40	71.0	59.3	15.75	8.70	6/22/56	Erie Co.
41	69.5	59.0	15.70	8.80	6/22/56	Erie Co.
42	71.0	58.7	16.55	10.00	6/22/56	Erie Co.
43	68.5	57.5	16.20	8.20	6/22/56	Erie Co.
45	72.0	59.3	16.60	8.40	6/23/56	Erie Co.
48	72.0	56.5	16.20	9.15	6/23/56	Erie Co.
49	72.0	58.2	15.30	9.10	6/24/56	Dunnville, Ont.
50	72.0	57.0	16.00	9.40	6/24/56	Dunnville, Ont.
DBW 221	69.0	56.8	15.09	9.00	6/13/56	Grand Island, Nebr.
225	70.0	58.8	17.25	9.50	6/15/56	Gothenburg, Nebr.
ROMZ 67053	71.5	58.9	16.45	9.55	5/16/41	Point Pelee, Ont.

* Birds labeled as being collected in "Larch Meadows" were actually taken at Fleming Meadows.

† Locations all New York State unless otherwise indicated.

Appendix Table 1 (*contd.*)

Measurements of morphological characters—Fee-bee-o males

CATALOG NO.	CHORD OF WING (mm.)	LENGTH OF TAIL (mm.)	LENGTH OF TARSUS (mm.)	LENGTH OF BILL (mm.)	DATE COLLECTED	LOCATION
RCS 55– 1	68.5	55.5	16.20	8.75	6/15/55	Ithaca (Airport)†
10	71.0	58.5	16.70	9.00	7/30/55	Ithaca (Airport)
11	70.0	58.0	16.40	8.50	8/1/55	Ithaca (Airport)
CU 23790	71.5	—	16.70	8.60	6/19/49	Brasher Falls
23791	71.0	58.0	16.90	8.80	6/17/49	Brasher Falls
23792	71.0	—	16.40	8.00	6/16/50	Delaware Co.
24163	71.0	59.0	17.20	9.40	8/4/53	Ithaca (Airport)
24164	71.5	60.5	16.10	8.60	8/4/53	Ithaca (Airport)
24167	70.5	57.0	17.40	9.40	7/29/53	Ithaca (Airport)
24453	69.5	58.0	17.00	8.60	8/12/53	Ithaca (Airport)
Cleve 13441	72.5	59.0	16.40	7.80	6/3/31	Jamestown
13442	71.5	57.5	16.10	8.10	6/3/31	Jamestown
RCS 56– 1	70.5	58.5	16.25	8.60	5/24/56	Ulster Co.
4	72.5	59.5	16.60	8.20	5/29/56	Danby (Beaver Pond)
5	75.0	61.0	16.60	9.10	5/29/56	Danby (Beaver Pond)
6	73.5	57.5	16.80	8.75	5/29/56	Danby (Beaver Pond)
8	73.5	58.0	15.80	8.10	5/30/56	Cattaraugus Co.
9	74.5	—	17.50	8.35	5/30/56	Cattaraugus Co.
10	71.5	61.0	16.80	9.60	5/30/56	Cattaraugus Co.
12	70.5	57.0	16.20	8.85	6/1/56	Cattaraugus Co.
13	71.5	59.0	17.10	8.40	6/2/56	Cattaraugus Co.
14	71.5	58.0	16.65	9.30	6/2/56	Cattaraugus Co.
15	73.0	57.5	17.10	8.25	6/2/56	Cattaraugus Co.
16	70.0	55.0	16.30	8.40	6/2/56	Cattaraugus Co.
17	70.5	56.0	16.15	8.70	6/2/56	Cattaraugus Co.
19	71.5	58.0	16.35	8.70	6/2/56	Cattaraugus Co.
21	70.5	56.5	17.05	8.00	6/2/56	Cattaraugus Co.
22	71.5	57.5	16.15	8.40	6/2/56	Cattaraugus Co.
27	70.0	56.0	16.30	9.40	6/13/56	Caroline Ctr.
28	70.0	58.0	16.40	8.70	6/13/56	Caroline Ctr.
29	72.0	59.5	16.20	8.00	6/13/56	Caroline Ctr.
30	69.0	57.0	16.35	8.20	6/13/56	Caroline Ctr.
32	74.5	59.0	17.75	8.90	6/18/56	Dryden Twp.
33	73.5	57.5	16.65	8.00	6/18/56	Dryden Twp.
44	73.5	58.0	16.15	7.60	6/22/56	Erie Co.
47	69.0	—	15.25	8.00	6/23/56	Erie Co.

† Locations are New York State.

Appendix Table 2A

Shrubs found in individual quadrats—Fitz-bews

FLEMING MEADOWS, HOG HOLE	QUADRAT, TERRITORY AND NEST NUMBER																						AVERAGE RATING OF COVER IN 5-METER QUADRATS	
	1954	55-1	55-2	55-3	55-4	55-5	55-7	55-8	55-9	55-10	55-12	55-13	55-21	56-1	56-2	56-3	56-4	56-5	56-6	56-7	56-8	56-13	56-15	NO.	AVERAGE
Cephalanthus occidentalis																				4*				1	0.17
Cornus alba stolonifera	2*		@4*	@2*	@3*	2*	*			2	*	4*		2*					@3*		1			10	1.09
amomum					2*																			1	0.09
racemosa												@2				4*							@3*	3	0.39
Prunus virginiana						*		*		2*		*		*							*		*	1	0.09
Pyrus malus						*								*										0	0.00
Rhus typhina	*	2										2*	*		2			*						3	0.27
Rubus allegheniensis											@4*													1	0.17
idaeus strigosis	2			*	*	2*		*		@3*	*		3*	2*								1	2	7	0.65
occidentalis		2*													2*									2	0.17
Salix fragilis		*				*								*	*									0	0.00
nigra				4*	2*		@5*		@4*												2*			5	0.74
rigida			2*																					1	0.09
Sambucus canadensis	@2*	@3*				@2*		@2*			2*		@4*	@2*	@3*	@2*	@5*	@4*		@2*	@3*	@5*		14	1.78
Ulmus americana																							*	0	0.00
Vitis vulpina riparia								3*					*					*				1*		2	0.17

@ = site of nest.
No. = rating as cover in 5-meter quadrats (see page 13).
* = present in 10-meter quadrats.

Appendix Table 2B

Shrubs found in individual quadrats—Fitz-bews

	QUADRAT, TERRITORY AND NEST NO.				AVERAGE RATING OF COVER IN 5-METER QUADRATS	
	SPENCER MARSH	DRYDEN LAKE	EAST ITHACA			
UPLAND AREAS	55-18	55-25	56-11	56-12	NO.	AVERAGE
Cornus alba	*	@3*			1	0.75
Cornus racemosa	@5*		1*	2*	3	2.00
Crataegus (? filipes)			@3*	@2*	2	1.25
Prunus virginiana				1	1	0.25
Rhus typhina			*		0	0.00
Salix discolor		3*			1	0.75
Salix nigra	*				0	0.00
Viburnum dentatum		2			1	0.50

Appendix Table 3A

Shrubs found in individual quadrats—Fee-bee-o's

	QUADRAT, TERRITORY AND NEST NO.					AVERAGE RATING OF COVER IN 5-METER QUADRATS	
MICHIGAN HOLLOW	1954A	55-19	56-18	56-25	56-26	NO.	AVERAGE
Alnus incana	1*	*		*	2*	2	0.60
Cornus alba	@2*					1	0.40
Pinus strobus					2*	1	0.40
Populus tremuloides	2*					1	0.40
Prunus virginiana		1*			1	2	0.40
Pyrus malus					1	1	0.20
Rhus typhina		1*				1	0.20
Ribes hirtellum	1					1	0.20
Rubus allegheniensis				2		1	0.40
Rubus idaeus		@5*	@5*		1	3	2.20
Salix bebbiana	2					1	0.40
Salix discolor	2					1	0.40
Spiraea alba				@4*	@3*	2	1.40

Appendix Table 3B

Shrubs found in individual quadrats—Fee-bee-o's

	QUADRAT, TERRITORY AND NEST NO.			AVERAGE RATING OF COVER IN 5-METER QUADRATS	
HORSE PASTURE	55-28	55-29	56-16	NO.	AVERAGE
Cornus racemosa	4*	@3*		2	2.33
Crataegus dodgei			@2*	1	0.67
(*? filipes*)	3*	2*		2	1.67
Lonicera tatarica			1*	1	0.33
Prunus serotina		2*		1	0.67
Pyrus malus			1*	1	0.33
Rosa cinnamomea	@1			1	0.33
Ulmus americana	*			0	0.00

Appendix Table 4A

Shrubs found in individual quadrats—Mixed populations of alder flycatchers

	FITZ-BEW (N=10)										AVERAGE RATING OF COVER IN 5-METER QUADRATS	
	QUADRAT, TERRITORY AND NEST NO.											
ITHACA-EAST HILL AIRPORT	55-20	55-26	56-9	56-10	56-14	56-20	56-21	56-22	56-23	56-24	NO.	AVERAGE
Cornus racemosa			1	2*				1	3*	2	5	0.90
Crataegus dodgei											0	0.00
Fraxinus pennsylvanicus										2*	1	0.20
Lonicera tatarica				1							1	0.10
Pinus strobus											0	0.00
Prunus serotina						1					1	0.10
Prunus virginiana		1									1	0.10
Rubus idaeus										2*	1	0.20
Salix bebbiana											0	0.00
Salix fragilis											0	0.00
Sambucus canadensis					1*						1	0.10
Ulmus americana							2*	2*	2*		3	0.60
Viburnum dentatum	@ 2*	@ 2*	@ 2*	@ 4*	@ 4*	@ 2*	@ 3*	@ 3*	@ 3*	@ 3*	10	2.80
Viburnum lentago											0	0.00

Appendix Table 4B

Shrubs found in individual quadrats—Mixed populations of alder flycatchers

		FEE-BEE-O (N=7)						AVERAGE RATING OF COVER IN 5-METER QUADRATS	
		QUADRAT, TERRITORY AND NEST NO.							
ITHACA-EAST HILL AIRPORT	1954B	55-11	55-14	55-15	55-17	55-22	55-23	NO.	AVERAGE
Cornus racemosa			3*	@3*		@3*	*	3	1.28
Crataegus dodgei					@3*			1	0.43
Fraxinus pennsylvanicus						1*		1	0.14
Lonicera tatarica								0	0.00
Pinus strobus						3*		1	0.43
Prunus serotina								0	0.00
Prunus virginiana			2*	*	1			2	0.43
Rubus idaeus		*		2				1	0.29
Salix bebbiana	@4*				1			2	0.71
Salix fragilis	1*	@3*						2	0.57
Sambucus canadensis								0	0.00
Ulmus americana							1*	1	0.14
Viburnum dentatum		2*	@2*	2*	1		4*	5	1.57
Viburnum lentago					2*		@2	2	0.57

Appendix Table 4C

Shrubs found in individual quadrats—Mixed populations of alder flycatchers

	QUADRAT, TERRITORY AND NEST NO.			AVERAGE RATING OF COVEP IN 5-METER QUADRATS	
	FITZ-BEW NEST	FEE-BEE-O NESTS			
ETNA SUBSTATION	55-6	56-17	56-19	NO.	AVERAGE
Crataegus (?punctata)	@2*	1		1	0.50
Cornus racemosa	2	@2*	1	2	1.50
Pyrus malus	2*	2*		1	1.00
Rubus occidentalis			@3*	1	1.50
Salix bebbiana	1			0	0.00
Salix discolor	2			0	0.00
Salix sericea	2*			0	0.00
Ulmus americana	1			0	0.00

Appendix Table 5

Occurrence and use of shrubs as nesting sites—by populations

	FITZ-BEW SONG-TYPE								FEE-BEE-O SONG-TYPE							
	FLEMING MEADOWS HOG HOLE		UPLAND EAST ITHACA		EAST HILL AIRPORT		ETNA SUB-STATION		MICHIGAN HOLLOW		HORSE PASTURE		EAST HILL AIRPORT		ETNA SUB-STATION	
	NO. NESTS	NO. QUAD-RATS	NO. NESTS	NO. QUAD-RATS	NO. NESTS	NO. QUAD-RATS	NO. NESTS	NO. QUAD-RATS	NO. NESTS	NO. QUAD-RATS	NO. NESTS	NO. QUAD-RATS	NO. NESTS	NO. QUAD-RATS	NO. NESTS	NO. QUAD-RATS
Cornus alba	4	12	1	2					1	1						
Cornus racemosa	2	3	1	3	0	5	0	1			1	2	2	4	1	2
Crataegus dodgei											1	1	1	1		
Crataegus (?filipes)			2	2							0	2				
Crataegus (?punctata)							1	1							0	1
Rosa cinnamomea											1	1				
Rubus allegheniensis	1	1							0	1						
Rubus idaeus	1	11			0	1			2	3			0	2		
Rubus occidentalis	0	2													1	1
Salix bebbiana							0	1	0	1			1	2		
Salix fragilis	0	4											1	2		
Salix nigra	2	5	0	1												
Sambucus canadensis	13	14			0	1										
Spiraea alba									2	2						
Viburnum dentatum			0	1	10	10							1	5		
Viburnum lentago													1	2		
Total	23		4		10		1		5		3		7		2	

Appendix Table 6

Individual measurements of eggs (in cm.)

Fitz-bews (30 eggs)			Fee-bee-o's (10 eggs)		
Nest no.	Length	Diameter	Nest no.	Length	Diameter
55–2	1.78	1.40	55–11	1.86	1.41
				1.81	1.42
55–3	1.81	1.38		1.77	1.46
				1.78	1.43
55–4	1.77	1.35			
	1.76	1.37	55–15	1.96	1.43
	1.76	1.39		1.96	1.43
	1.77	1.35			
			55–17	1.78	1.37
55–6	1.77	1.40		1.79	1.37
	1.76	1.39		1.82	1.36
	1.76	1.39			
	1.79	1.41	55–19	1.98	1.38
55–7	1.74	1.37			
55–8	1.70	1.29			
	1.79	1.37			
	1.75	1.31			
	1.84	1.39			
55–9	1.86	1.32			
	1.87	1.39			
	1.97	1.38			
	1.85	1.38			
55–10	1.78	1.36			
55–12	1.81	1.40			
	1.87	1.38			
	1.81	1.38			
	1.80	1.40			
55–13	1.73	1.33			
	1.78	1.35			
	1.79	1.35			
	1.81	1.37			
55–21	1.75	1.37			
	1.71	1.35			

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By

William A. Ritchie
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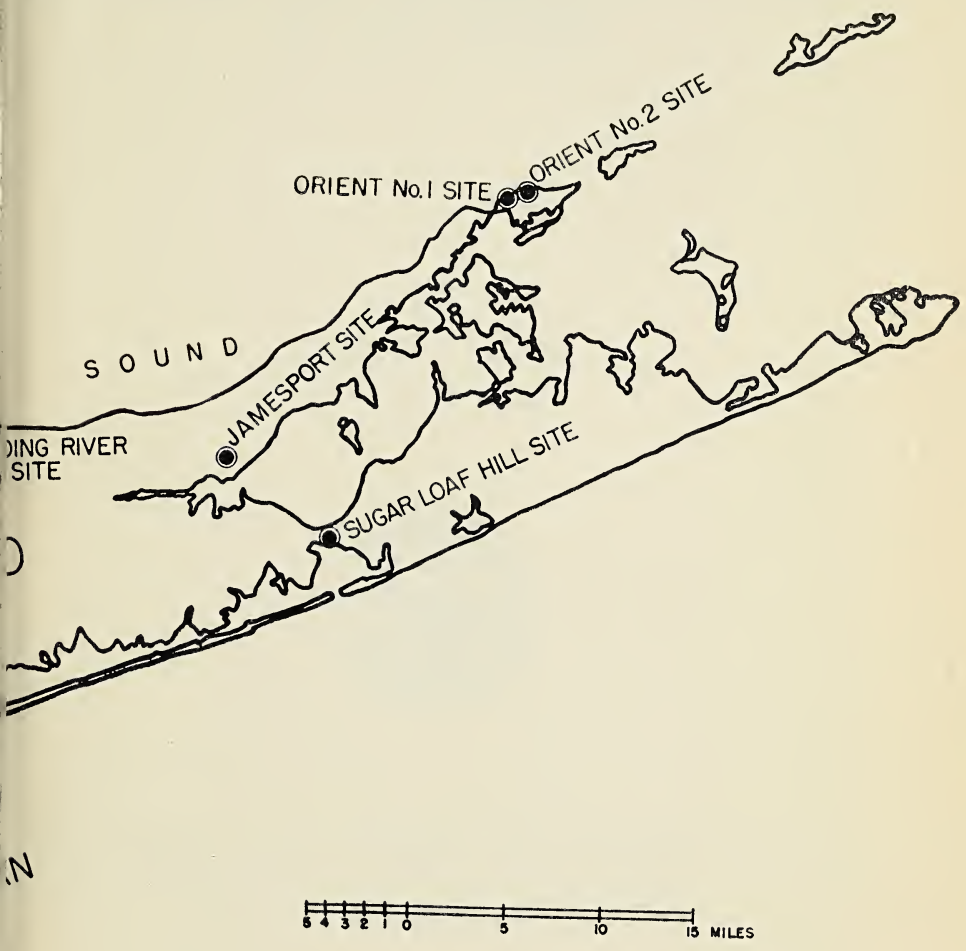
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SUGAR LOAF HILL SITE
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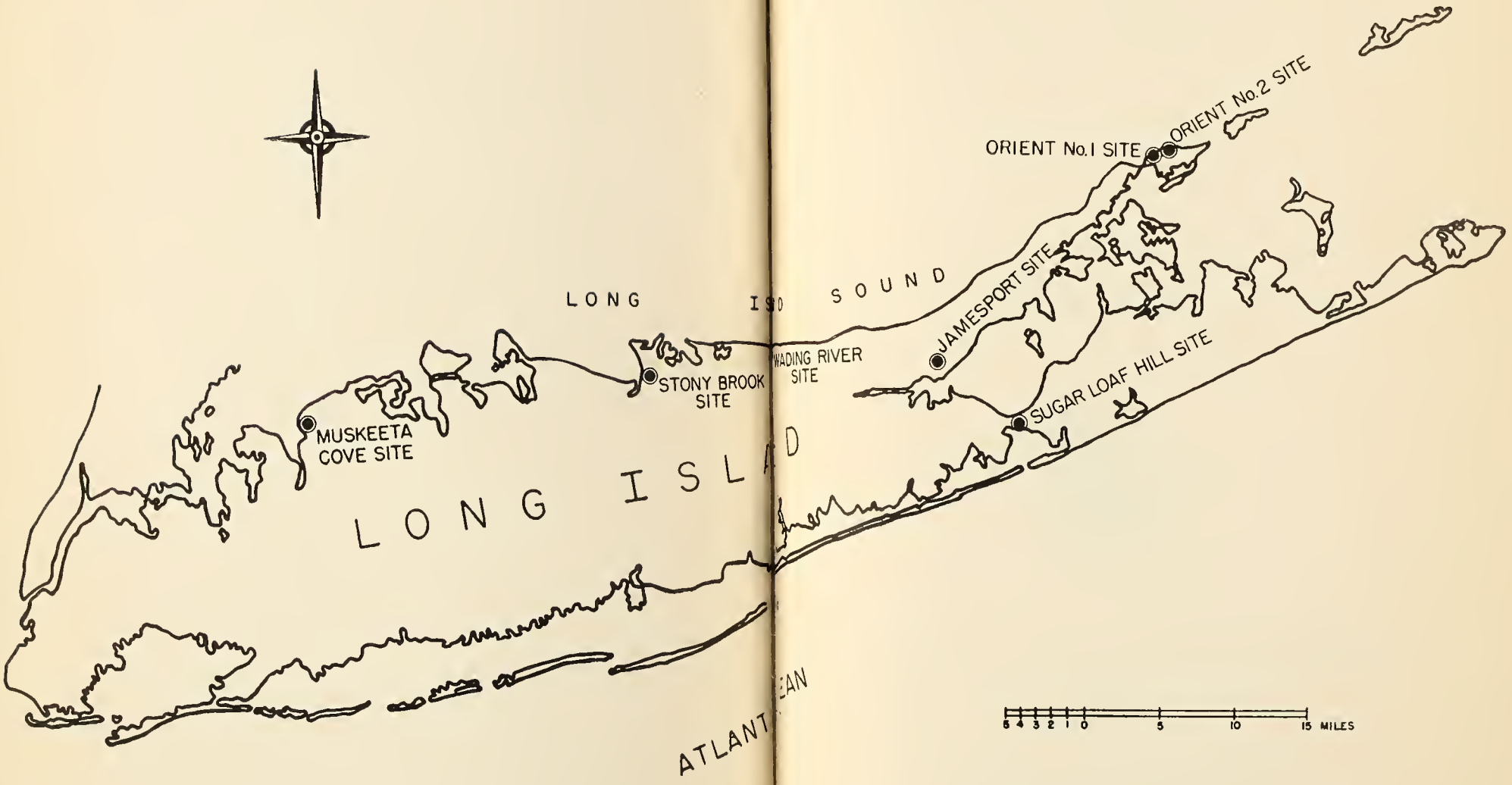
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ORIENT No.2 SITE
JAMESPORT SITE
WADING RIVER SITE
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MUSKEETA COVE SITE
SUGAR LOAF HILL SITE
LONG ISLAND
ATLANTIC OCEAN
5 4 3 2 1 0 5 10 15 MILES

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The Stony Brook Site and Its Relation to Archaic and Transitional Cultures on Long Island

By William A. Ritchie,
State Archeologist, New York State Museum and Science Service

Preface

Coastal New York, of which Long Island forms the principal segment, appears on current evidence to have been visited or inhabited by man since about 5000 B. C. Two recorded examples of the Clovis style of fluted point, one of the earliest known New World projectile forms, found near Greenport and Bridgehampton, respectively, apparently attest to the brief presence of the paleo-Indian on eastern Long Island. More numerous examples of this widely distributed pre-Folsom point, dated before 10,000 years ago in the southern plains and desert basin area of New Mexico and Arizona, occur in the Hudson Valley and north of Long Island Sound in lower New England.[1]

After about 3000 B. C., by extrapolation from radiocarbon dated central and eastern New York sites,[2] and for more than 2,000 years, the Coastal region shared with inland New York and adjacent areas, a sparse and scattered population of hunters, fishermen and collectors of wild vegetal foods, in an Archaic stage of culture.[3] These people seem to have had a central-based wandering community pattern,[4] that is, during most of the year they moved from place to place, living for varying periods of time on the local food resources, and spent the remaining time at a semipermanent base camp to which they brought preservable wild foods, such as acorns and smoked or dried meat and fish. One such band of preceramic transients left its humble stone artifacts in the lower or older midden accumulation at Stony Brook. Still another and probably earlier Archaic group was responsible for the different types of projectile points found by us at Wading River and described later in this report.

[1] Ritchie, 1957.
[2] Ritchie, 1951, p. 31; 1958, p. 67.
[3] Ritchie, n.d.
[4] Meggers, 1956, pp. 138-140.

A relatively little understood phase of cultural transition connects the preceramic Late Archaic manifestations of southern, eastern and portions of central New York, as well as northeastern New Jersey and Pennsylvania and parts of southern New England, with ceramic cultures of the Woodland period. This transition appears to have involved the introduction into these areas of a new complex of ideas and material objects but not to have altered the basic food gathering economy or general way of life. Stone cooking pots and, in some regions, a variety of point styles with "fishtail" bases constitute the principal indicators of the changing archeological picture,[5] which was soon to be further and more substantially modified by the addition, apparently from another source and direction, of a simple pottery ware and an elaborate mortuary ritualism.[6]

The upper or more recent midden deposits at Stony Brook, as will be shown, relate to a habitation site of this transitional period (only one other such site is known[7]), and they yielded significant data which, as will later be explained, link this manifestation with the Orient mortuary complex.

Thus the excavations of the New York State Museum and Science Service at Stony Brook, supplemented by its recent work at Wading River, Jamesport and Sugar Loaf Hill, all on eastern Long Island, have for the first time brought into relatively clear perspective the character and relationships of major Archaic and Early Woodland cultures in coastal New York, and so have established a firmer foundation for the subsequent Indian history of the area, so well summarized in Carlyle S. Smith's *The Archaeology of Coastal New York*.[8]

Stony Brook Site

UNLIKE THE MAJORITY OF ARCHEOLOGICAL sites on Long Island and, indeed, throughout much of the Northeast, the Stony Brook site, although known to a few local people, was undisturbed when reported in July 1955 to William H. Sears of the reconnaissance party of the State Museum, by Mr. P. Roger Smith of Stony Brook, whose unselfish cooperation is gratefully acknowledged. Because of the site's intact condition it was possible from the start of operations to plan and execute a systematic excavation and to discern vital stratigraphic relations which are often largely obscured on a heavily vandalized site.

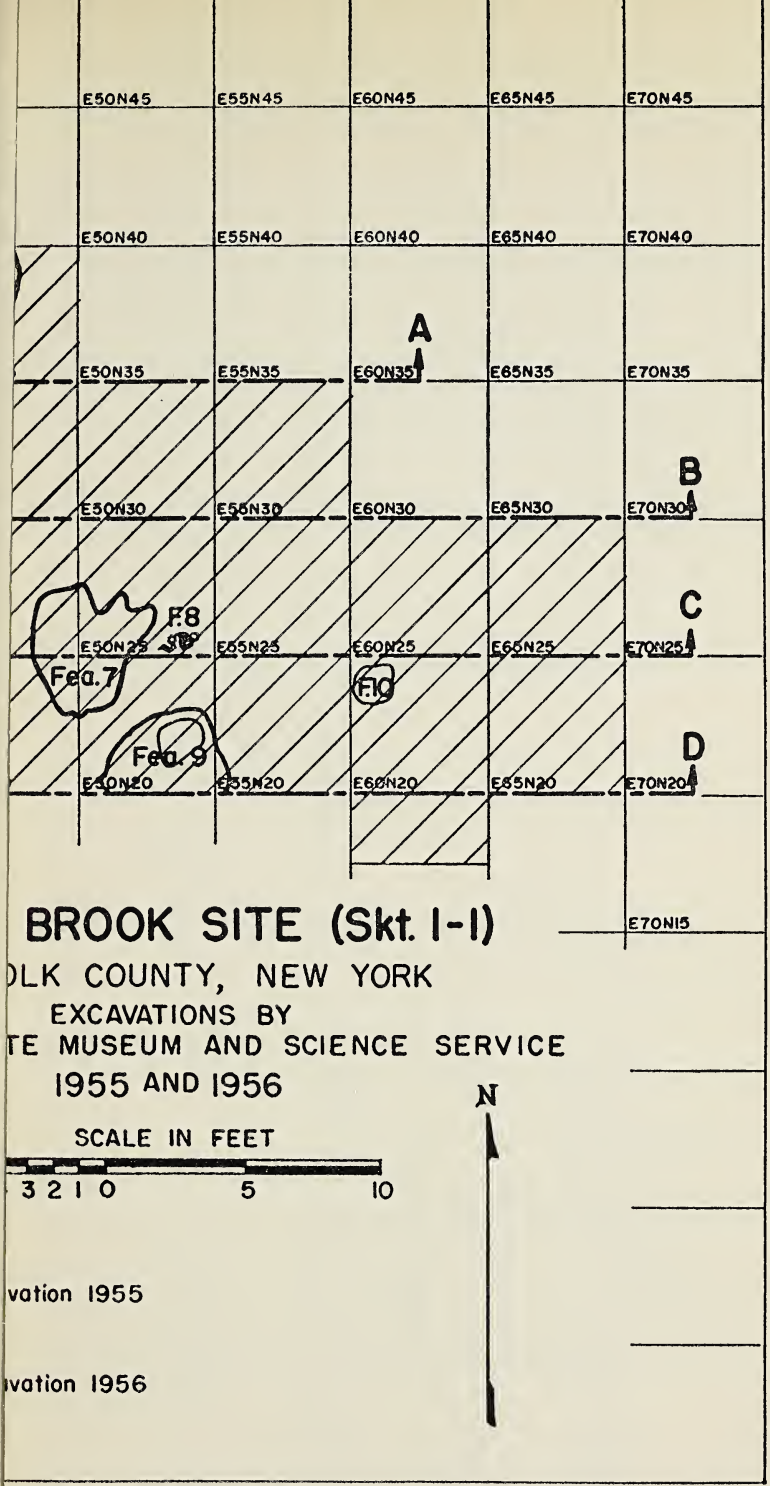
When brought to our attention, the tract of land containing the site had already been surveyed into residential building lots and comprised

[5] Witthoft, 1953, pp. 23-26.

[6] Ritchie, 1955, pp. 67-76.

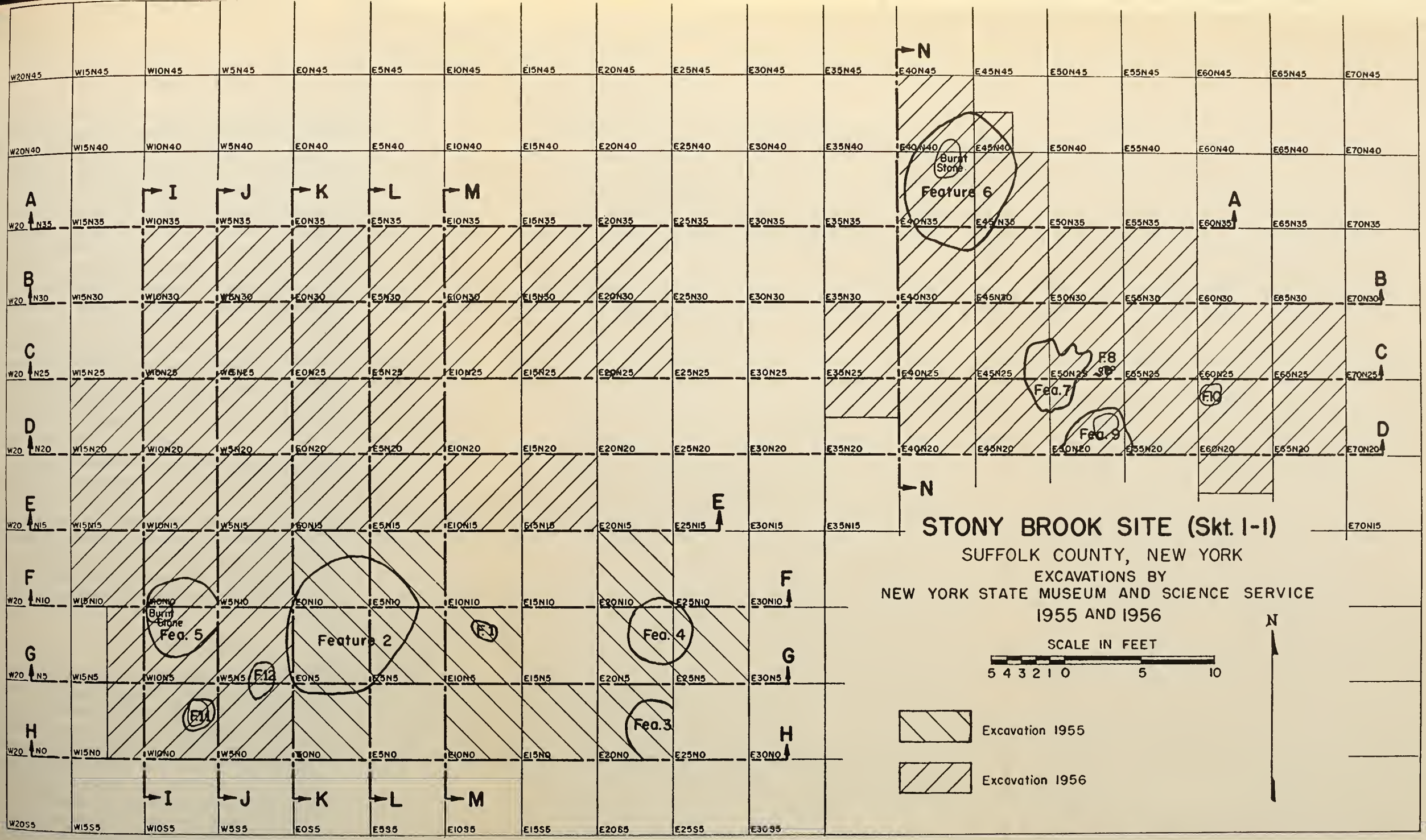
[7] The Muskeeta Cove site at Glen Cove on western Long Island, excavated by the Nassau Archeological Society (Patterson, n.d.).

[8] Smith, 1950.



Feature 11, Hearth 5

of profiles given in figures 2 and 3



PITS
Feature 2, Pit 1 — Feature 4, Pit 3 — Feature 6, Pit 5
Feature 3, Pit 2 — Feature 5, Pit 4

BURIAL
Feature 8, Burial 1

HEARTHS
Feature 1, Hearth 1 — Feature 9, Hearth 3 — Feature 11, Hearth 5
Feature 7, Hearth 2 — Feature 10, Hearth 4

OTHER
Feature 12, Dog Bones

Figure 1. Grid plan of the Stony Brook site, showing excavated areas and location of features and section lines (A-N) of profiles given in figures 2 and 3

section 3 of the Stony Brook Shores Corporation, although construction had not yet begun. Our request for permission to explore the land, made through the corporation's vice president, Mr. T. Bayles Minuse, brought enthusiastic and generous support, for which our hearty thanks are expressed to Mr. Minuse and other members of the corporation.

The preliminary work of 1955, carried out by the writer, assisted by William R. Young and Walter F. Knowlson, consumed 16 days and consisted in the excavation of 12 5-foot sections of the site (see figure 1), from which I inferred its potential significance as a habitation site of the Orient complex. Between July 11 and August 19, 1956, an additional 55 squares were explored (see figure 1) by a party comprising James V. Wright, Galen B. Ritchie and John W. Fenton II, under a research grant generously made to the Board of Regents by Mr. Ward Melville of Stony Brook. During the first week this party was reinforced by the State Museum unit comprising William R. Young, Douglas F. Jordan and the writer. Later, by alternating between the two parties, when the Museum unit conducted the Sugar Loaf Hill and Wading River digs, the writer actively directed the work of both groups.

When, at the close of the 1956 field season at Stony Brook, it became evident that the greater part of the site had been thoroughly investigated, Mr. Melville further expressed his interest by making a second grant in aid for publishing the results of the researches and to procure radiocarbon analyses of charcoal samples from the site. On behalf of all concerned, it is a pleasure to record our grateful thanks to Mr. Melville.

In the performance of various friendly services we are also indebted to Messrs. Kenneth West and George G. Firth of Stony Brook.

LOCATION

The Stony Brook site occupies a gentle slope lying between Night Heron Drive and the north shore of Aunt Amy's Creek, on Stony Brook Shores, section 3, situated approximately two miles northeast by road from the business center of the pleasant community of Stony Brook, Town of Brookhaven, Suffolk County, N. Y.[9] About 850 feet west of the site this stream joins the larger West Meadow Creek, flowing south into Porpoise Channel near the latter's entrance into Smithtown Bay of Long Island Sound.

At the threshold of the historic period, about A. D. 1600 in this area, the locality is believed to have been included at the western limits of the territory of the Setauket tribe or chieftancy of the Montauk Confederacy

[9] Lat. 40° 56′ 05″ N., Long. 73° 08′ 30″ W. See St. James, N. Y. 7.5 minute quadrangle, U. S. Army Corps of Engineers.

of Long Island Algonkian Indians.[10] Unfortunately, nothing is known of the historic or prehistoric archeology of the Setaukets, so it is impossible to attribute anything at the Stony Brook site to the ancestors of the historic occupants of the district. Moreover, the age of the Orient, or later component at the site, has been radiocarbon dated to a period far too remote to admit, in the current lack of intermediate phases, of a plausible connection with a definite tribal or linguistic group.

Despite the passage of some three millenia, certain of the natural advantages which we may assume to have been responsible for the Indians' choice of locality are still evident. Since "no fundamental ecologic difference exists between a human community and any other special type of animal community,"[11] these factors comprise such cardinal considerations as available food resources and protection against climatic rigors. The contents of the extensive shell middens on the site furnish the clue to the first of these requirements, met by direct and easy communicability by water with the still more or less abundant local sources of shellfish, waterfowl and other aquatic animals of the neighboring tidal bays and marshes.

The south-facing site opens to the sun across the marshy expanse of Aunt Amy's Creek; behind it, to the north, cold winds are blocked by a high ridge rising rather steeply to a maximum elevation of 80 feet above mean sea level. This highland is part of the Harbor Hill Ridge, an ice-marginal morainal feature traversing northern Long Island from west to east, tentatively referred to the Iowan-Tazewell complex of the Wisconsin glacial period.[12]

Several springs are reported to have formerly existed along the base of this hill near the site.

Erosion of this ridge of sand and gravel was apparently responsible for the well-drained, sandy, terrace-like slope, on which the site was situated, just below the 25-foot contour level, the approximate location of the present roadway (Night Heron Drive).

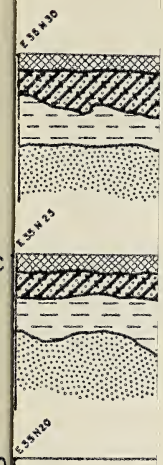
EXCAVATIONS

The area of the site was densely covered with an undergrowth of Japanese honeysuckle interspersed with cat brier and thin patches of poison ivy, and was sparsely wooded with red cedar, various oaks, butternut and pitch pine (plate 1). Our first task, after clearing the major obstructions, was to establish a grid of 5-foot squares, measuring 80 feet by 105 feet,

[10] "The Setalcot, or Setauket, tribe claimed from Stony Brook to the Wading River, and was one of the most powerful tribes in the county. They inhabited the sides of the different creeks, coves and harbors, and also Little Neck (now called Strong's Neck), which is supposed to have been a royal residence" (Thompson, 1918, p. 126). "They sold their last remaining lands in 1675" (Hodge, ed. 1910, p. 514).

[11] Dice, 1955, p. 3.

[12] Fleming, 1935, pp. 216-227; Flint, 1953, p. 900, pl. 2.



Stony Brook

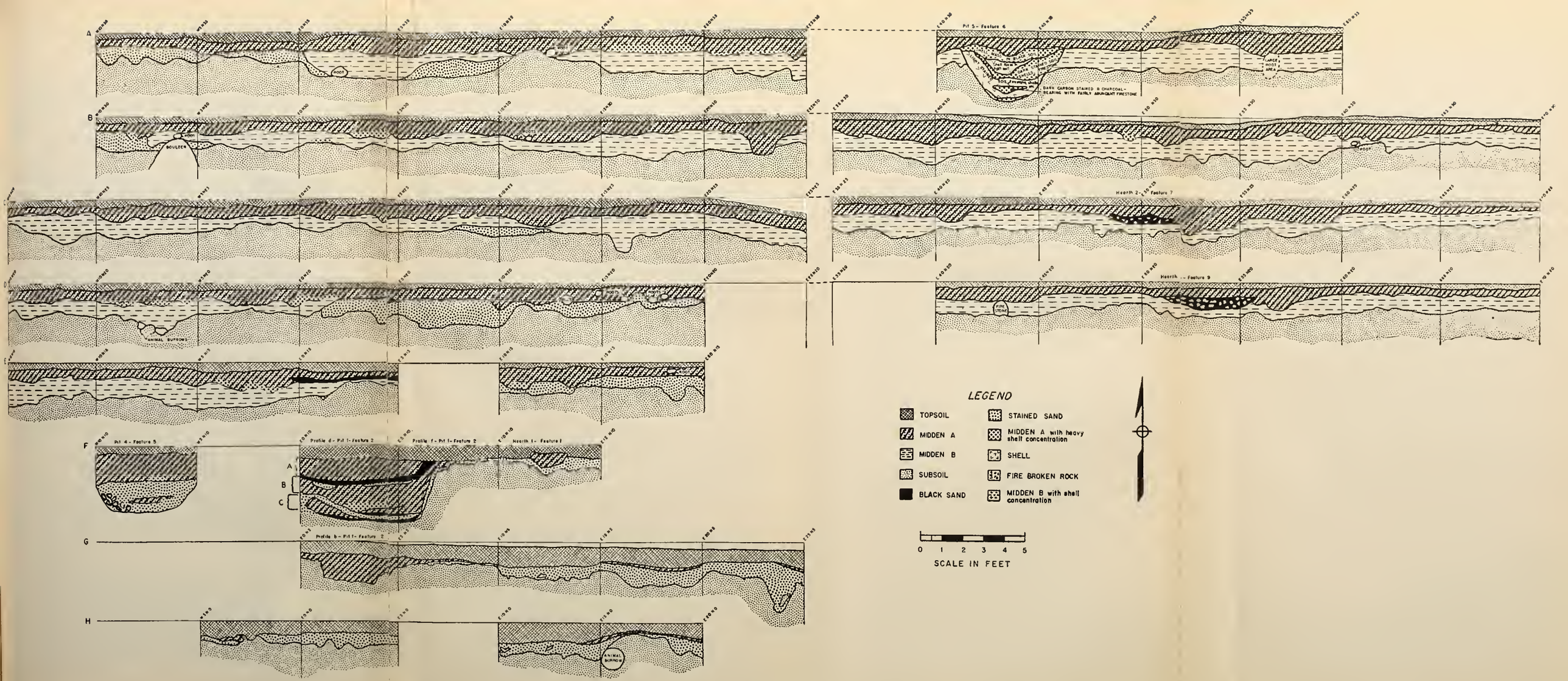


Figure 2. East-west profiles (A-H) on Stony Brook site

with north-south and east-west coordinates (figure 1). Excavations began along the east-west baseline where test-pitting showed the midden to be thinning out as it approached the swampy margin of Aunt Amy's Creek. The method employed consisted, after thorough stripping of the vegetation cover, in establishing an initial 2-foot trench along the coordinates from the E0N0 prime stake for a distance of 5 feet north, east and west, and then excavating each 5-foot square progressively in these directions.

Two men worked side by side on each section, using a combination of horizontal and vertical cutting with the trowel, first to remove the upper few inches of nearly sterile topsoil, then to dissect the midden material an inch or two at a time (plates 2, 3). Features, such as hearths and the single burial, were fully exposed (plates 16-18); pits were exposed and sectioned in various ways to study their structure and contents (plates 3-14, figures 2-4); profiles of every wall section were carefully drawn and many were photographed in color and black and white (figures 2, 3 and plates 4-7, 10-12, 15); the horizontal location of all artifacts was recorded by triangulation or reference to coordinates, the vertical position by measurement of exact depth and stratigraphic provenience.

STRATIGRAPHY

The site was, for the most part, well stratified, the various layers maintaining their relative relationships throughout. The few disturbances noted were due to tree roots or burrowing rodents rather than to previous archeological or other digging. No positive evidence of plowing could be detected. The fills were various and, beginning at the surface, may be described as follows:

1. A fine, granular, dark, sandy topsoil mantle, some 2 to 9 inches thick, heavily interlaced with roots, chiefly of the Japanese honeysuckle. It seems mainly to have been formed since the site was abandoned by its Indian occupants, through the accumulation of humus and probably some soil-creep from the hill. The very sparse Indian material (shell fragments, quartz chips, burned stones and an occasional projectile point or potsherd) occurred almost entirely near the base, which merged gradually into the layer beneath.

2. This underlying layer, continuous over most of the site and varying considerably in thickness and composition, comprised the younger and principal midden, consisting of very dark sand containing granules of charcoal, crushed or whole mollusk shells, bones of various animals, the rejectage of a quartz pebble industry, occasional artifacts and numerous fire-shattered stones. It also constituted the major fill of the pits, where in particular it was often associated with dense, black lenses or layers, com-

posed of sand and diffused charcoal and humus or other highly organic content. In short, it comprised the "Indian dirt" left by the paramount occupants of the site, the people of the Orient culture and possibly, in very minor part, a still later folk. Hereinafter, it will be referred to as Midden A.

3. Tentatively defined in the first season's brief operation, confirmed in 1956, and of more limited distribution than the midden mantle just described, was a light gray sand containing occasional shell fragments, charcoal particles, burned stones, quartz rejectage and artifacts mainly differing in type from those of the superincumbent darker Midden A layer. (See figures 2, 3.) This was interpreted as an older, underlying midden, intact for the most part, but partly or wholly destroyed in some places by intrusive pits relating to the Orient occupation. It will subsequently be referred to as Midden B.

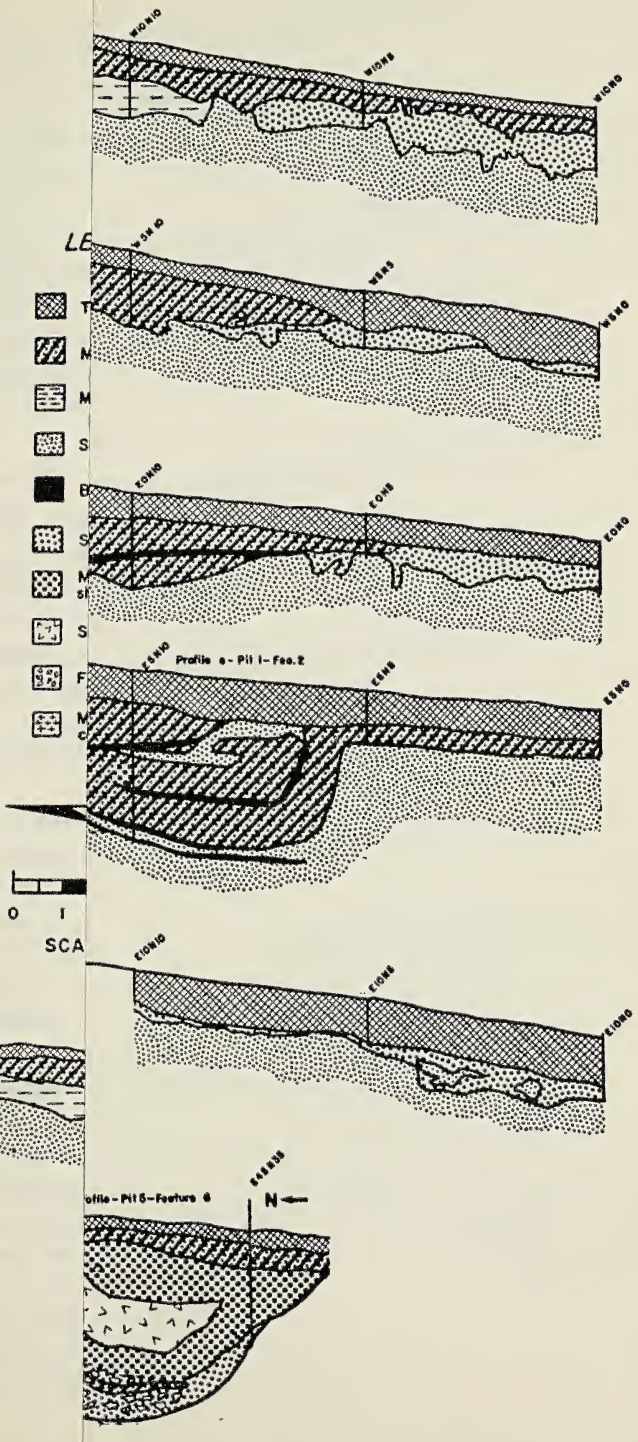
4. It was sometimes difficult to differentiate visually between (1) midden fill and (2) irregular downward extensions of stained sand. These resulted from leaching by percolating rainwater of humates and humic acid into the subsoil level of the site (figures 2, 3). Industrial material was but rarely found in this stained sand, and then usually through obvious intrusion.

5. The basal or subsoil member, archeologically almost sterile, everywhere consisted of morainal material, a tan sand carrying many white quartz and a relatively low percentage of brown or russet red quartzite pebbles, ranging in size up to small cobbles, derived by glacial transport from vein quartz, probably in Connecticut. Occasional pebbles or cobbles of granitic and other rock were present, primarily an arkose constituted of sandstone or quartzose conglomerate with hematite cement, whose source was the sedimentary rocks of Triassic age in the Connecticut valley.[13] These waterworn arkose pebbles, often of rude dish-shape (plate 22, figure 28), are commonly referred to on Long Island as "Indian paint-cups" and, indeed, occasionally such pebbles with a high hematite content show scraping or grinding to obtain this red pigment (plate 22, figures 29, 30). The Orient people were especially fond of this "paint," as will later be shown.

FEATURES

Features found on the site were neither numerous nor complex. For the most part they comprised pits, hearths and a single burial.

[13] Identification by Kurt Servos, Curator of Geology, State Museum (Krynine, 1950, pp. 98-102).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W10N5
W10N0
W5N10
W5N5
W5N0
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E5N5
E5N0
Profile a - Pit 1 - Fea. 2
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SCA
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E40N45
E45E35
N

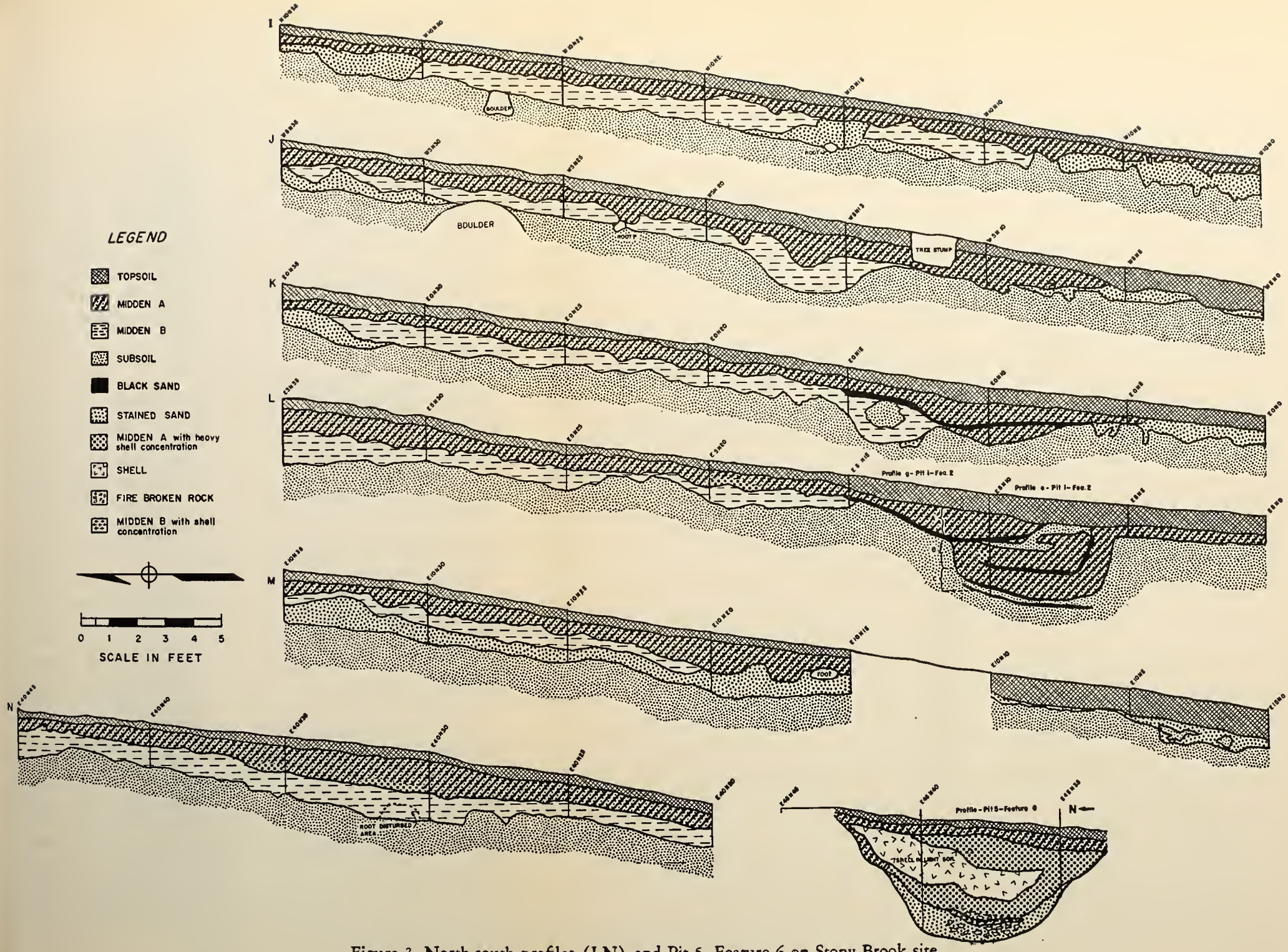

Figure 3. North-south profiles (I-N) and Pit 5, Feature 6 on Stony Brook site

Pits

Five of these structures were found and carefully excavated in various parts of the site (figure 1). They were referred to as Features 2-6. All preserved evidence of multiple use, apparently as shellfish baking ovens, suggesting repeated occupation, perhaps seasonally, by the Orient folk responsible for the accumulation of Midden A, from some level of which all pits seemed to originate. The people associated with the older Midden B, although they too were to some extent shellfish users, appear not to have been pit diggers but to have cooked on small hearths or open fires, sometimes with the aid of stones as a hearth-bed (plate 17).

Because the Stony Brook site is unique, being the only systematically excavated habitation site of the Orient culture, a reasonably full account will be given of each pit and other features.

Pit 1 (Feature 2)

Excavated in August 1955, Pit 1 and Pit 5 were the largest found. Pit 1 occupied most of section E0N5 and portions of E0N10, E5N10, E5N5, with a maximum diameter of about 9 feet and depth of 4 feet and can best be comprehended by reference to ground plan and profiles, figures 1-4, and photographs, plates 3-6.

Apparently it consisted of three superimposed fill complexes, designated A, B and C, respectively, each composed of a black sand layer and shell mass, with a partial layer of sandy wash intervening between the A and B complexes.

The feature was covered by an undisturbed 5-inch layer of topsoil which mantled a compact dark midden mass containing many whole and crushed shells of the oyster, hard clam and scallop and, especially near the top in the northwestern section, a scattered layer of fire-broken stones (plate 5). This portion of the fill was underlaid by a dense, homogeneous, black sand layer, forming a broad basin-shaped deposit, enclosed near the center of which occurred a thick lens or pocket of hard, burned-red sand. Bits of enclosed charcoal suggest a small hearth.

The contemporaneity of the shell fill and the black stratum, together comprising A, is attested by the finding of potsherds of the same style (apparently even from the same vessel) in each, the first, shown in plate 24, figure 6, on the shoulder of the pit at 9 inches from the surface, the second, a very small sherd, at 12 inches in the shell detritus, the third embedded in black sand near the bottom of the stratum, at 17 inches from the surface (plate 24, figure 7).

The thick, irregular segment of light-colored sterile sand, resembling subsoil, already mentioned, and well shown in the illustrations (figures 3 and 4 and plate 5), was considered a wash from northeast of the pit

during an indeterminate interval of disuse of the pit or site, following the basal accumulation of unit B, now to be described. This comprised another dark shell midden mass of eccentric shape, but roughly lenticular. Where the lower black zone of A impinged upon the dark B deposit, a narrow, very black and compact zone of separation was evident, serving to emphasize the otherwise indicated time lapse between the A and B accumulations.

Complex C consisted of a thick, nearly horizontal stratum of dark sand, with a little crushed shell, resting upon the basal layer of the pit, a third compact band of black sand (see figure 2).

Thus it would seem that the original U-shaped pit, dug deeply into the subsoil, had been successively employed, on at least three major occasions, in the cooking of shellfish, receiving after each such use the detritus of the feast. The whole history of the pit may encompass a single season, or even less, or it may span the activities of a single group over several years. No direct clue is given here to the manner of cooking, but it would appear that the dense black bands represent the residue of fires, since the dark color seems to have been imparted by the heavy volume of minute granules of charcoal. In other features of this kind, subsequently to be described, burned stone and sand were present beneath similar bands. We may therefore suppose that the pit was heated with fires kindled in the bottom, then the shellfish baked within, perhaps under the insulating cover of a wet mat or mass of vegetation.

As to the cultural identity of the people involved, some slender but adequate clues are afforded by the industrial contents. The three small sherds of dentate-stamped pottery, ranging in depth from 9 to 17 inches, from the A section, already mentioned, comprised the total ceramic remains of the pit. One complete projectile point, a point reject, and two broken tips of points were also present in the A zone. Of these, the first, a well-formed example of the Orient Fishtail type, and the second are diagnostically useful (plate 20, figures 5, 19). The whole point lay 18½ inches down, near the base of the upper shell deposit; the fishtail reject at 11 inches in the dark fill at the top of the pit.

The B complex yielded another broken quartz point tip and a second Orient point at 20 inches in the black sand, close to the A contact margin (plate 20, figure 8).

In the C portion of the pit were found two superb examples of the same specific point form (plate 20, figures 1, 3), at 22 and 34 inches, respectively, below the surface, the first in the sandy, the second in the bottom black layer within 2 inches of the subsoil.

We may accordingly conclude that the entire Feature 2 pertained to a single cultural group, the Orient, and it would now appear that dentate-marked pottery was a late trait of this culture at the Stony Brook site.

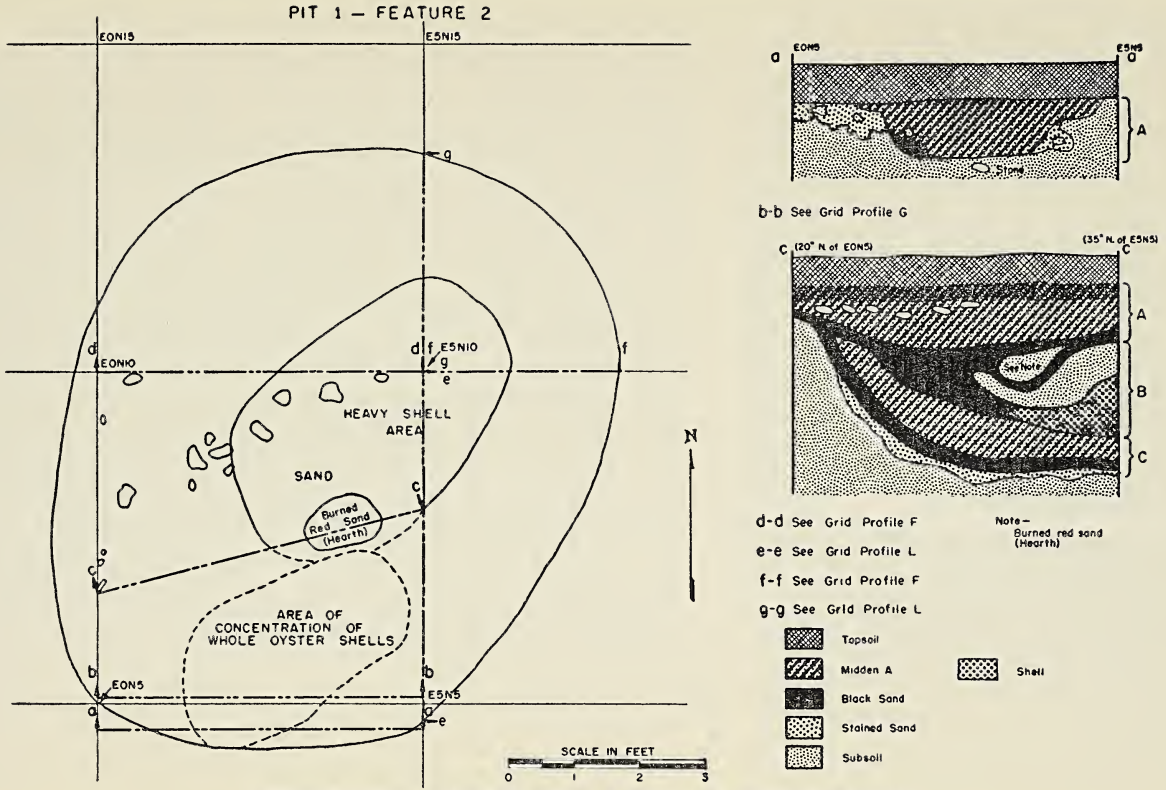

Figure 4. Plan and profiles of Pit 1, Feature 2, Stony Brook site

Pit 2 (Feature 3)

Found in sections E20N0 and E25N0, this pit had a 4-foot diameter and a maximum depth of 31 inches (figure 1). Like Pit 1, it was U-shaped, intruding into the subsoil from a level in Midden A only a few inches below the base of the topsoil zone, and was therefore a recent feature of the site. An almost solidly packed core of shells of scallop, with some hard clam, oyster and a few whelk, measuring about 40 inches in diameter, extended from top nearly to bottom. Black sand surrounded the lower shells and was particularly deep at the bottom, where it held many fire-broken stones and was underlaid with burned sand. Burned shells were also present in this portion of the fill and the case for a baking pit was stronger than in Pit 1.

Contained artifacts were a side-notched point at 8 inches near the pit edge (plate 21, figure 7), a fishtail point in two pieces among the shells at 12 and 13 inches (plate 20, figure 17), and a point tip at 24 inches.

Pit 3 (Feature 4)

This feature lay only a few feet north of Pit 2 in sections E20N5, E25N5, E20N10 and E25N10 (figure 1) and was similar in size, structure and content. The diameter was 50 inches, the depth from surface 32 inches, the depth from base of topsoil, the approximate oral level, 24 inches. The greater portion of the contents consisted of almost clean, solidly packed valves of the scallop, hard clam and oyster, in descending order of abundance. In the upper third of the pit most of the shells were broken, as though heavily trampled, while those below were entire.

Black sand with many broken stones invested the bottom and lower sides of the pit, and the subsoil beneath these portions was distinctly burned to an orange-red color. Some of the shells found in this feature bore, on their sides, scorched or burned spots an inch or so in diameter, further supporting the inference that the pit had functioned primarily in the preparation of food, then incidentally as a garbage repository.

The following artifacts served to connect this feature with the other pits: the basal portion of a fishtail point at 9½ inches in the shell mass (plate 20, figure 14), a rude, side-notched point fragment at 19 inches along the pit wall (plate 21, figure 17), a broken ovate knife at 24 inches and a hematite paintstone at 20¼ inches (plate 22, figure 30). In the burned sand covering the bottom were five quartz pebble discards, illustrating various stages of blade or point manufacture (plate 23, figures 2, 3). Two others occurred higher in the fill, at 7 and 15 inches, respectively.

Pit 4 (Feature 5)

This is the first of the two pits excavated during the 1956 operations. Situated in sections W10N5 and W10N10, it had a 5-foot diameter and

a 40-inch maximum depth below the surface (figure 1). The feature was first visible as a compact mass of grayish ash and bits of scallop shell, quartz chips, small bone fragments, fire-cracked stones and charcoal particles, 7 to 9 inches from the surface in the general Midden A mantle (plate 7 and figure 2). Removal of this mantle and upper fill of the feature disclosed a nearly circular, saucer-shaped depression in the subsoil, filled with very dark sand (plate 8). When this had been removed, the northeastern quadrant of the bottom was found to contain an oval cluster of broken cobbles of granitic rocks and quartzite, which had been subjected to fire *in situ,* as shown by the burned orange-colored surrounding subsoil and small, loose splinters of rock (plate 9). Charcoal granules and shell and bone particles, were present in the lower as in the upper fill. Unfortunately, the only artifact within the pit confines was a small body sherd of unmarked pottery at 13 inches from the surface, but other sherds, points and a stone pot fragment came from the midden fill of the same sections.

Pit 5 (Feature 6)

This, the largest pit found, covering most of section E40N35 and parts of the adjacent five squares (see ground plan on figure 1), had an oval oral measuring 9 feet 3 inches by 7 feet 3 inches. The maximum depth was 4 feet 2 inches. Beneath the topsoil cover, 2 to 4 inches thick, an unbroken zone of dark Midden A soil, 4 to 10 inches deep, graded imperceptibly into a bowl-shaped mass of similar dark soil and shell, reaching a maximum thickness of 22 inches (figures 2, 3 and plates 10 and 11). Much of the upper shell was fragmented, as in Pit 3, while that below was intact. Scallop valves predominated, with a considerable intermixture of hard and soft clams and oysters. A few whelk shells were also present. From this body of debris came approximately a quart of deer bones, broken into pieces no longer than 2 or 3 inches, bits of charcoal, and the usual burned stones and quartz rejectage. There were also six minute potsherds, evidently from a single vessel, at 4, 9, 10, 15, 17 and 20 inches (plate 24, figure 2). None was found below this level of the pit. There were also a rude splinter bone awl at 13 inches and the base of a crude side-notched point at 22 inches (plate 21, figure 16).

The next fill member consisted of a broad, irregularly meniscoid layer of light sand carrying scallop, clam and oyster shell, particles of deer bone, quartz chips and the proximal portion of a lobate-stemmed projectile point at 13 inches along the shoulder of the pit (plate 22, figure 5).

A rather confused lensing of dark and light sand occurred below this fill (see profiles, figures 2, 3). Apparently another dark sand, shell and stone-

bearing layer was present which yielded the only vegetal food remains found on the site, a carbonized fragment of hickory nut.

Contrary to prevailing pit conditions, the lowermost fill of Pit 5 consisted of a light-colored sand with few shells, but abundant broken stones and the largest amount of charcoal found in any feature. This was present in discrete fragments ranging up to about one-fourth inch in size and totaling some 68 grams, which were carefully collected and constituted one of the two samples submitted for radiocarbon dating and reported on below.

In this zone of maximum charcoal, approximately 40 to 50 inches below the surface, were found a point discard of fishtail form at 42 inches and a large, stemmed, spearpoint base, one of the few flint artifacts recovered from the site, at 40 inches (plate 21, figure 31).

The density of firestones increased as the bottom of the pit was reached and the northwest portion of the wide, basin-shaped floor was covered with a long oval heap of these shattered granitic and schistose cobbles, measuring 32 by 22 by 5 inches (plates 12-14). A little shell and bone refuse lay among the stones, which were bedded in burned sand.

As in Pit 2, conditions in this feature reflect a history of multiple usage, beginning with the hearth just described and encompassing at least three successive episodes of employment as shellfish cooking and disposal pits. Finally the structure was capped by the general Midden A deposit.

Hearths

In addition to the aggregates of burned stone already described as fireplaces created for cooking in the several pits, five other features, not situated in pits, were interpreted as hearths. These varied more in character than those of the pit group, and will be described individually.

Hearth 1 (Feature 1)

Situated in the northcentral part of section E10N5, this feature comprised an irregular deposit of black sand, burned stones and charred shells, measuring 22 by 14 by 9 inches. It occupied an oval depression dug into subsoil from a level 4 inches below the top of the Midden A layer (8 inches from surface), and was thus of approximately the same age as most of the pits. Humic acid stain extended beneath it in the light subsoil.

While no artifacts were present in or in close association with this hearth, two fishtail points occurred in the same square, one in the topsoil layer in the northeast corner (plate 20, figure 11), the second, a process piece at 5 inches deep, 16 inches southwest of the hearth (plate 20, figure 13).

Hearth 2 (Feature 7)

This large feature of the stone platform variety occupied portions of sections E45N20-25, E50N20-25, as shown in figure 1. In general character it resembled the much smaller stone hearths from the bottoms of Pits 4 and 5, in that it consisted of an irregularly shaped bed of fire-broken cobbles of quartz, granitic and schistose rocks, varying in depth from 2 to 6 inches (averaging about 4 inches) and measuring 4 feet 9 inches across (see plate 16).

It lay at the base of the Midden A mantle, here having a maximum thickness of 10 inches (beneath 4 inches of topsoil), rested upon the lower, older Midden B, and seemed therefore to pertain to the level of Orient occupation. (See plates 15 and 16 and figure 2.)

While discrete particles of charcoal were scarce among the stones, a very black, carbonaceous material, suggesting amorphous charcoal, was present over, among and under the stones, as may be seen in plate 15. No burned soil, however, could be detected beneath the feature, a point of sharp contrast with the next to be described hearth.

In the immediate vicinity of the stone bed quite numerous split bones of the deer were collected, a few of which were recovered from within the feature itself.

Two artifacts of no culturally diagnostic value were present in more or less direct association, a rude ovate blade or reject of quartz among the upper stones and a bone splinter awl at 5½ inches from the surface in the covering midden (plate 22, figure 1). Under the hearth, in the Midden B soil, 23½ inches from the surface, a fishtail point was troweled out. As this point came from an obvious root channel leading downward from Midden A, it is believed to have been intrusive from the superior level (plate 20, figure 12).

Hearth 2 may have been a baking or roasting area for venison and other meat, perhaps including shellfish. Small fires may have been kindled on the stones from time to time, and the food to be cooked placed upon the heated bed, under an insulating cover of some kind. After many successive uses, the feature became incorporated in the growing midden accumulation.

Generally similar structures have been reported for Archaic and later period sites in New England,[14] New York[15] and elsewhere.

Hearth 3 (Feature 9)

Quite possibly related to Hearth 2 (Feature 7), from which it was separated only by about one foot, was the feature now to be considered. It

[14] Praus, 1942, pp. 24-27; 1945, pp. 11-13.
[15] Ritchie, 1928, pp. 14, 15; 1945, p. 7.

covered most of the southern half of section E50N20 and extended into the adjacent unexcavated section E50N15.

Like Hearth 2, it rested upon Midden B, under an apparently undisturbed 8 inches of combined topsoil and Midden A material. Fifty-eight inches in diameter, it consisted of a lenticular mass of burned sand, resulting from extensive fires built upon the surface of the lower midden (see figure 2). Within the area of mottled brown and red sand occurred a smaller circular patch, some 20 inches in diameter, of indurated, brick-red soil, evidently the locus of most intensive heat (see figure 1).

In and about the sand were scattered burned rock fragments, small pieces of carbonized or calcined animal bone, and some discards of the quartz pebble industry. Because of the lack of burned soil under Hearth 2 and the absence of a definite bed of cooking stones in Hearth 3, it is possible that many of the stones found in the former feature were actually heated in the latter hearth. This raises the suggestion of a sweat-house structure, to which stones heated on a nearby fire were transferred (with wooden tongs?) for the purpose of creating the necessary steam for the sweating ritual or therapeutic practice, as recorded by various observers among the northeastern Indian tribes.[16] Both these features seem too large to represent a single instance of use, but reiterated employment might have resulted in the evidence uncovered.

Hearth 4 (Feature 10)

In the northwest corner of section E60N20 was discovered the only feature which could convincingly be attributed to the older or Midden B occupation of the site. This was a small hearth measuring 17 by 14 by 8 inches, filling a roughly bowl-shaped depression and wholly enclosed in the subsoil zone (see figure 1 and plate 17). To the top of this mass of charcoal-stained sand, the distance was 28 inches, of which 4 inches were topsoil, 4 inches Midden A, 10 inches Midden B and 10 inches apparently unmolested subsoil. The contents were saved but the carbon, obtained by the flotation process, was insufficient for radiocarbon analysis.

Hearth 5 (Feature 11)

What may have been a small hearth was uncovered near the eastcentral edge of section W10N0. It comprised a compact mass of black sand with a high carbon content (sample collected proved inadequate for a radiocarbon test), firestones, carbonized deer bones and clam shells. The area of maximum concentration covered 22 by 16 inches and was 4 inches in maximum thickness. It was surrounded by a somewhat wider zone of less intensive hearth evidence (see figure 1). As this feature was encom-

[16] Van der Donck, 1841, p. 208; Jameson, 1909, p. 218; Butler, 1945, pp. 11-15.

passed within Midden A, with its top situated only 7 inches beneath the surface, it clearly relates to the Orient culture level of the site.

Burial 1 (Feature 8)

Until the excavation of the Stony Brook site, the Orient culture was known only as a mortuary complex on eastern Long Island.[17] The evident burial ritualism of the Orient folk, as illuminated by recent discoveries, will later be discussed in this report. We must here record, regretfully, that our test-pitting of the high ridge behind the site and of a prominent knoll on Crane Neck Point, overlooking Smithtown Bay and Long Island Sound about 2½ miles northwest of the site, produced no clue to the locus of a related cemetery. The nearest such is still at Jamesport, approximately 28 miles to the east;[18] while the cemetery (Orient No. 2), Carbon-14 dated as contemporaneous with the Stony Brook site, lies some 18 miles farther east than Jamesport. (See pp. 52-67.)

At Stony Brook the only human remains found consisted of the skeleton of a very young infant, shown *in situ* in its flexed position on the left side, head to east and facing south, on plates 16 and 18. The body seemed to have been laid on the surface of Midden A, only a couple of inches above the latter's contact with the underlying Midden B, and covered with midden material consisting of the usual dark soil, shell and other detritus, since no grave pit outlines could be detected. Its close proximity, on the same level (15 inches from the surface), to Hearth 2, Feature 7 (plate 16), and the absence of intrusive evidence, suggest that it belongs to the Orient level of the site. I suspect that the infant may have been interred here by some grieving mother mindful of the comfortable warmth of the nearby hearth.[19]

No offerings, at least of an imperishable nature, had been left with the body. The frail bones had suffered pressure fracturing, loss of the lumbar vertebrae, and displacement of the left tibia and fibula, by rodent disturbance.

Feature 12

In the northern midportion of section W5N0 and the adjoining area of W5N5 were found scattered bones of a dog, under circumstances which preclude positive identification as a burial (see figure 1). The articulated

[17] Ritchie, 1944, pp. 227-235; Latham, 1953.

[18] Ritchie, 1944, pp. 231-232.

[19] An analogous, but more ancient, instance of infant burial in the (assumed) warm ashes of a camp fire, with dog and other accompaniments, was found by the writer on the Frontenac Island site in central New York (Ritchie, 1945, burial 23, pp. 52, 128-129).

pelvis, lumbar vertebrae and one femur occurred in W5N0, near the base of Midden A (Midden B was lacking from the southern area of the site, see Profiles F-H, figure 2), at 10-13 inches from the surface and adjacent to a mass of shells. Other bones of the skeleton, found on the same level of the neighboring square (W5N5), included the skull with shattered vault, lodged vertically against a root, as pictured in plate 19.

Rodent burrows were not observed, nor was there other evidence of post-Indian disturbance. It seems unlikely that this degree of lateral displacement would be root-engendered. More plausibly, the remains pertain to an animal killed for food, a trait recorded for the historic Algonkian tribes of the general area.[20] This assumption is supported by the discovery of isolated dog bones, not derived from this skeleton, found singly in scattered sections of the site.

Unfortunately, the remains are too defective to permit a description of the animal. It has been possible to restore from fragments the right femur and tibia which yield the following measurements: femoral length, 150 millimeters; greatest transverse breadth of distal condyle, 28 millimeters; tibial length, 155.5 millimeters; maximum breadth of proximal condyle, 30 millimeters.

Comparison of these scanty data with the available inadequate information, suggests a size intermediate between the larger or common and the short-legged Indian dogs.[21]

In our specimen the mandibles are not amenable to detailed mensuration. The lower carnassial tooth measures 20 millimeters in length, the upper m1 16.5 millimeters. Since there is an overlap in respect to these dimensions between the breeds referred to, this dental information is of little present help.

ARTIFACTS

The artifact yield of the Stony Brook site was low, even by comparison with the average Long Island habitation component. Projectile points numbered 101, comprising 76.5 percent of the total of 131 nonpottery objects. Bone implements, limited to a few simple awls and a probable flaking tool, numbered 8 (6.1 percent). There was but one small shell ornament. Potsherds, as reassembled, comprised some 58 fragments, mostly small.

Nevertheless, it is possible to extract from this meager industrial content certain significant clues to the economic activities of the site's inhabitants,

[20] Anon., 1856, p. 283; de Laet, 1841, p. 300; Drake, 1841, p. 54; Butler and Hadlock, 1949, pp. 21-24, 27-29.

[21] Allen, 1920, pp. 457-463, 464-469.

as well as to their cultural and temporal relationships with other groups on Long Island and elsewhere in the northeastern area. In major part this analysis depends upon specific projectile point typology, for most of the forms here involved possess a high degree of diagnostic value, according to present understanding.

Orient Fishtail Type Points

Foremost within this category is the distinctive style which I have long referred to as the "fishtail" form and which I have recently designated the Orient Fishtail type.[22] A formal description will follow immediately and the type is illustrated on plate 20. Suffice here to state that it characterizes the Orient culture of Long Island and seems to constitute a horizon marker for the Late Archaic-Early Woodland transitional zone in eastern and southern New York.

Its distribution on the Stony Brook site is such as clearly to indicate its upper level provenience, i. e., as an implement of the people responsible for Midden A, the pits, most of the hearths and the burial feature. With its associated traits, in these portions of the site, especially the stone pot and paintstones, it affords strong evidence linking the upper component with the Orient mortuary complex. The statement of provenience is based upon the data given in the following section which show that 6 examples of this point type (12 percent of total) came from the topsoil zone, 32 (64 percent) from Midden A, 8 (16 percent) from features referable to the Midden A occupational horizon, and only 4 (8 percent) to Midden B. Of the latter, one example (#41687-2)[23] is tentatively identified in this class; another (41728-5, plate 20, figure 12), was found in a root channel leading downward from Hearth 2 (Feature 7), and was probably intrusive from the upper level of the site.

In every case, the material of these points is the local quartz or quartzite. That they were manufactured on the site from suitable pebbles found in the glacial drift is established by the presence in the same levels where the points occur of ample chipping rejectage, illustrating various stages of completion. Their typological identity with the points of the Orient mortuary complex is equally well shown by a comparison of plates 20, 30-33, 45, 46, the latter from our excavations on Orient cemetery sites at Jamesport and Sugar Loaf Hill.

Orient Fishtail Point Type

Material: Chipped quartz, quartzite, flint or slate, with few exceptions.

[22] Ritchie, 1958, p. 68.
[23] Indicates permanent catalog number.

General description: A slender, gracefully formed point, with characteristically narrow lanceolate blade merging into a flaring "fishtail" stem.

Size: Length range of 71 excavated points from Orient sites described in this report, 1-15/32—4 inches, breadth 11/16—1-3/16 inches, thickness 1/4—9/32 inch. Average measurements of random sample of 19, approximately 2-3/32 inches long, 3/4 inch wide, and 5/16 inch thick.

Proportions: About 3.5 times as long as wide.

Shape: Blade lanceolate, with shoulders merging into flaring stem with incurvate base.

Variants: A variant, possibly an intermediate form, chiefly found in the middle and lower Hudson Valley, has a proportionally broader blade and a nearly straight or straight base. (See plate 53, figures 5-8.)

Association: Late Archaic-Early Woodland transition period, embracing the stone vessel and early ceramic horizons in the area of its distribution.

Distribution: Eastern and southern New York, particularly the middle and lower Hudson Valley and Long Island. Has a light, sporadic, representation in central New York, southern New England and northeastern New Jersey.

References: Ritchie, 1944, p. 227; 1958.

Stemmed and Side-notched Points

Next in order of frequency and diagnostic value in the projectile point inventory are the stemmed and side-notched forms illustrated on plate 21, whose horizontal and vertical provenience is also recorded in the following section. This group includes three general subvarieties, viz., a heavy, broad-bladed style (plate 21, figures 6, 13, 14, 22-37), a proportionally narrower bladed variety (figures 4, 5, 15-19) and a very small form (figures 1-3, 7-12, 20, 21). Except for the prevailing quartz material, the first two groups are indistinguishable in essential shape and size characteristics from styles prevalent on numerous sites in the Northeast, attributed to various complexes of the Laurentian tradition, of the Middle and Late Archaic periods.

The third group, comprising the very small variety, has its closest parallels in the Lamoka Stemmed and Lamoka Side-Notched types of central and western New York, and especially in what seem to be regional variants of these types, present in eastern New York and southern New England.[24] The Lamoka types relate to a still undesignated Early Archaic

[24] Ritchie, 1958, pp. 12, 14, 31-33, 45, 59-61, 68.

tradition which seems to have been assimilated into the succeeding, dominant Laurentian tradition.[25]

At Stony Brook these various stemmed and side-notched points were distributed in such fashion as to indicate their intrinsic relationship to the older or Midden B horizon. Taking the group as a whole, the topsoil level furnished but 4 examples (9.5 percent), Midden A and its associated features 13 examples (31 percent), while 25 or 59.5 percent came from Midden B. Their presence in the upper context may, perhaps, best be explained by the assumption of derivation from the lower level by the pit digging and other activities of the subsequent Orient occupants. Another alternative, to be later elaborated, supposes a continuity of habitation by a single cultural group, with a gradual change in point style preference, resulting from the diffusion of the fishtail form into an essentially Laurentian complex, where it eventually replaced the older point styles.

Lozenge-shaped and Lobate-stemmed Points

Only two examples of each of these possibly related classes occurred on the site, all found in the Midden A level. Those of the first category are very narrow, with pointed base (plate 22, figures 19, 20); of the second, incomplete (plate 22, figures 4, 5).

Relatively little is known about the age and associations of these forms. Skinner records a "double-ended type," which is a broader variety of our lozenge-shaped form, as having been found with typical examples of our Orient Fishtail type, and other styles, in the lower levels of the Throgs Neck shell-heap in the Bronx;[26] Smith illustrates lozenge, lobate, fishtail and all the forms we have described as Archaic from Stony Brook, as pertaining to the preceramic horizon of the Grantville site on western Long Island.[27] I strongly suspect here a mixture of components of various ages. The lozenge and fishtail forms he also attributes to the North Beach focus, his first ceramic horizon.[28]

To the lobate-stemmed form, at least, I would assign an Early Woodland provenience. Available data suggest its derivation from the Ohio Valley, whence it entered New York through the Allegeny Valley with other traits of the Adena tradition. It seems to have reached eastern New York via the Mohawk Valley and, in the Hudson Valley and coastal New York, to have overlapped with the period when the Orient Fishtail type reached its climax.[29]

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[25] Ibid., pp. 31-32, 70-71, 99-100.

[26] Skinner, 1919, pp. 64, 70. The lozenge-shaped point is also found in the Red Valley Focus of New Jersey, associated with the bannerstone, gouge, knobbed adze and other artifacts (Cross, 1941, pp. 122-127, 210-211).

[27] Smith, 1950, p. 143.

[28] Ibid., p. 135.

[29] Ritchie, 1958, pp. 100-101.

Triangular Points

Like the last described forms, these are a negligible constituent at the site. The best example is short, broad, with concave base, and of grey cherty stone (plate 22, figure 13). It was found in the topsoil, 6½ inches from the surface in section W5N0. Another, also from the topsoil, at 2 inches, in section E0N30, appears to be an unfinished equilateral triangle of quartz (plate 22, figure 12). The remaining specimens, of quartz, from Midden A, are of isosceles pattern, and one seems crude and uncompleted (plate 22, figures 6, 11). The cultural and temporal position of such artifacts in the coastal sequence is not yet clear. Smith illustrates triangular points for each of his cultural manifestations,[30] and it would appear that this region formed no exception in the Northeast in showing an increase in frequency of popularity of the relatively thin equilateral triangle with the advance of the Woodland period. At Stony Brook I suspect that the triangles may be related to the shell-tempered Sebonac(?) pottery as later intrusions into the Orient horizon.

Ovate and Trianguloid Knives

This somewhat tentative classification of what may be only exceptionally refined projectile point blanks is based upon congruence of form with established typologies in other early cultures of the general area, and upon the sharp, thin, cutting edges of the artifacts in question, despite their general crudity and thickness.

Seven in all, they were about evenly divided between Middens A and B, as noted in the following section. All are of quartz; the length range is from 1½ to 3-5/16 inches, the breadth range from ⅜ to 13/16 of an inch. Most of the specimens are pictured on plate 22, figures 21-26.

Drills

Stone perforators or drills were represented only by 4 fragments, 3 tip sections of gray flint (plate 22, figures 14-16), and one basal portion of quartz (figure 17). The latter is one of two artifacts found in the subsoil. It came from a depth of 26 inches in section W5N30. Deriving from this level, its general resemblance to an Orient Fishtail point is difficult to explain in terms of the expressed hypothesis of cultural succession on this site.

One of the specimens is from Midden B (plate 22, figure 15), the others are from Midden A. Stone drills are a known trait of Laurentian, Orient and later complexes.

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[30] Smith, 1950.

Scraper (?)

On plate 22, figure 18 depicts a thick prismatic flake of black flint, found 4 inches from the surface in the topsoil level of section W5N25. On its broader end occurs a series of minute flake scars, resulting either from use or fine retouch, possibly as a scraping tool. The otherwise total absence of scrapers from this site is noteworthy in supporting the negative evidence from the Orient mortuary complex.

Hammer and Anvilstones

Three hammerstones of simple pebble type with battered ends came from Midden A at various places in the site (see following section). Two are of quartz (plate 23, figures 14, 15); the third is an elongate sandstone cobble (figure 19).

A broken flat quartz pebble with a scarified area on one face (figure 18) is the only identifiable anvilstone. Considering the great abundance of quartz wastage from a pebble industry, the scarcity of stone chipping tools is surprising. A small series illustrating progressive stages in the reduction of a quartz pebble to a projectile point is given in plate 23, figures 1-13.

Celt (?)

So badly shattered, evidently by fire, is the thin, rude, side-notched, and roughly ground-edged sandstone artifact, pictured on plate 23, figure 16, that its identification as the only ground stone cutting tool found on the site is rather problematical. It came from Midden B in section W5N25, at 10 inches from the surface.

Paintstones

In this brief description of the paintstones we return to artifacts with culturally diagnostic significance, since such specimens occur in some numbers in all Orient mortuary assemblages. Two water-worn arkose pebbles, with a high percentage of hematite cement, are portrayed on plate 22, figures 29, 30. The first is from Midden A, section E10N0, at 8 inches from the surface; the second from Pit 3, Feature 4, 20¼ inches down. Both have a long edge ground for the production of the desired red pigment. On plate 22, figure 28 illustrates one of the many unworked, natural arkose pebbles found during the course of our excavations. (See page 18.)

The well-worked piece of pure graphite, shown as figure 27 of the same plate, came also from Midden A (section E40N20, depth 10½ inches).

It has been extensively rubbed, grooved and cut to obtain the silver gray pigment. Potential sources of this mineral are the Adirondack Mountain area, especially Lewis County, N. Y.; southeastern Pennsylvania, and the western Connecticut highlands. All of these areas also produce soft rocks suitable for the manufacture of cooking pots, a distinctive trait of the Orient culture.

Stone Potsherds

These, with the fishtail points and paintstones, have a high diagnostic value for the Orient culture complex on Long Island, as will be evident in the subsequent discussion of the finds at Jamesport and Sugar Loaf Hill. The two large fragments, which have been united in the pot section given as figure 17 of plate 23, came from adjacent sections (W5N10 and W10N10), at depths of 11 and 8 inches, respectively, in Midden A. The wall is very thick, averaging an inch, the lug or handle, prominent. The material has been identified as amphibolite. This occurs in various localities of southern New England and may have been locally available on Long Island in glacial drift boulders.[31] This subject is discussed more fully on pages 62-64.

Bone Artifacts

Because of soil conditions propitious for the preservation of bone,[32] the sparsity of artifacts of osseous material can be attributed only to cultural factors. The relative scarcity of bone and antler as compared with chipped stone artifacts in Laurentian complexes has long been recognized.[33] For the Orient culture there were no prior data on which to predicate an expectancy, since only burned bone fragments had survived in the mortuary pits. It would now appear, from the Stony Brook evidence, that the bone and antler constituent in the Orient complex was definitely weak.

Our small inventory, detailed in the following section, comprised only 5 splinter awls from the upper level (plate 22, figures 1, 2, 9) and two from Midden B (figures 7, 8). Additionally, there is a round, flaker-like tool of sea mammal (?) bone, badly shattered on one end, blunted and battered on the other (plate 22, figure 3), from 9 inches deep, in Midden A, section W10N5.

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[31] Identification by Mary C. Reed, Curator of Geology, N. Y. S. Museum.

[32] Truog soil pH tests, made by Donald P. Connola, Senior Scientist (Entomology) of the N. Y. State Museum and Science Service, gave the following results: Midden A, 8.0; Midden B, 7.8; subsoil, 7.5. All are in the range where free calcium carbonate should be present.

[33] Ritchie, 1940.

Shell Ornament

The small (diameter c. ½ inch), crudely made, discoidal shell bead, illustrated on plate 22, figure 10, is the single shell artifact from the site. It was fashioned by breaking, rubbing and drilling a fragment of whelk whorl. The provenience is section E20N25 of Midden A, depth 6½ inches.

Pottery

There were 118 potsherds found during the course of our excavations at Stony Brook, most of them of very small size and, with few exceptions, confined to the upper levels of Midden A. It has been possible to combine some of these fragments into larger sherds more amenable to comparative study and to assign all but 16 minute or badly damaged pieces to five tentative type categories. Of these, one may eventually be demonstrated a new type, diagnostic of the Orient culture. Further data on the ceramic constituent, now to be described, are given in the following section, Inventory and Distribution of Artifacts.

Stony Brook Corded (tentative new type)

The 59 sherds of this ware have been in part assembled into 16 sherds, some illustrated on plate 24, figures 9, 10, 14. The paste is granular in texture and sandy to the touch; the temper is a fine to coarse crushed crystalline rock, in moderate amounts, plus much sand which was possibly native to the clay. No evidence can be detected of the method of manufacture. The color range is from moderate reddish brown (10 R 4/6),[34] through moderate yellowish brown (10 YR 5/4), to moderate brown (5 YR 4/4); is the same on both surfaces, while small areas of the core are dark gray (N 3) due to lack of oxidation in the firing process. The hardness ranges from 2.5 to 3;[35] the thickness from 7 to 15 millimeters. The exterior surface finish was applied haphazardly by malleation with a cord-wrapped paddle. The interior is smooth. There are no rim sherds to indicate a possible, but very unlikely, decoration of this portion of the pot. The body diameter of the partially restored vessel was about 8½ inches. The shape is indeterminate.

This pottery does not resemble any described by Smith for the coastal area of New York, hence we are provisionally regarding it as a new type. As will later be shown, the scanty ceramic remains from the Orient cemeteries at Jamesport and Sugar Loaf Hill have similarities to this ware category.

[34] On the Rock-Color Chart, distributed by the National Research Council, Washington, D. C., 1948.

[35] On the Moh's Hardness Scale.

The bulk of this material at Stony Brook comprised 50 sherds of one pot (see plate 24, figures 9, 10, 14) which were found together in two overlapping layers embedded in the top of Midden A, at 8 inches from the surface, in section W5N5. With one exception (41719-3), a sherd found in section E20N30, in Midden B, beneath a deeply penetrating tree root mass, and probably intrusive, all sherds of this type pertained to Midden A, and mostly to its upper portion.

North Beach Brushed (?) (Smith, 1950, p. 196)

The 13 sherds of this provisionally identified type have been combined by partial restoration into 5 sherds, 2 of which are rims (plate 24, figures 11-13). The paste has a granular texture and is heavily tempered with coarsely crushed stone particles. The larger rim sherd (figure 11) has a weakly laminated structure with less abundant aplastic. The color is dark yellowish brown (10 YR 4/2) in 4, brownish gray (5 YR 4/1) in the larger rim. The hardness is 2.5; the thickness 10 to 14 millimeters. Exterior and interior surfaces are crudely smoothed and, on the larger rim, bear fine, parallel lines, produced by wiping or brushing. These are also present on the interior of the smaller rim (figure 12). The rim sherds are vertical, with the upper wall thinning to a narrow, rounded lip. Body and base shape are unknown.

There is considerable resemblance to the Point Peninsula Plain type, except that the latter has a slight neck constriction and rim eversion, also minor decoration of lip and interior rim.[36]

All are from Midden A or the topsoil level (see following section for details).

Vinette 1 (?)[37]

A single small sherd, probably of this early type, corded over both surfaces, came from near the top of Midden A, in section E55N25 (plate 24, figure 8).

Matinecock Point Stamped (?) (Smith, 1950, p. 196)

Tentatively so classified are 7 body sherds having a granular paste, moderately to abundantly tempered with coarse grit, composed of angular quartz fragments, small pebbles and, in two cases, a few pieces of shell. One example seems to have been entirely shell-tempered but most of the particles have been leached out, possibly by humic acid in the upper level of Midden A, where 4 sherds occurred, the others coming from the A complex of Pit 1. Coil surfaces are visible on one sherd. The hardness is

[36] Ritchie and MacNeish, 1949, p. 103.
[37] Ibid., p. 100.

2.5; the thickness 10 millimeters; the color light brown (5 YR 5/6). Both surfaces are smooth, the exterior is scantily decorated with impressions of a linear-dentate stamp. (Plate 24, figures 5-7.)

Sebonac Stamped (?) (Smith, 1950, p. 194)

Here, again, the material is too small and scarce to admit of positive identification. Two of 20 small body sherds have a compact, shell-tempered paste; are moderate brown (5 YR 4/4) and grayish brown (5 YR 3/2) outside, respectively, and black on the inner surface, and have a hardness of 2.5. The inside has been horizontally brushed, the outside vertically combed with a coarse-toothed instrument. Faint transverse incisions cross these on one sherd, while both exhibit a faint overlay of scallop shell imprints (plate 24, figures 3, 4).

Figure 1 of the same plate portrays the largest reassembled portion of a single pot, represented by 18 body and, probably, two small rim sections, all found in close proximity in the top portion of Midden A, section W10N5. The laminated, shell-tempered paste of these sherds has a hardness of 3, a thickness of 5-7 millimeters, and varies in color from moderate yellowish brown (10 YR 5/4) to grayish brown (5 YR 3/2). The neck section is smooth, the body finely corded, the interior brushed horizontally. A row of parallel, oblique, scallop shell-imprinted lines, 10 millimeters in length, encircles the base of the neck. Fine incised lines and triangular punctations occur on one rim fragment (plate 24, figure 2). The lip is nearly flat. There is a moderate degree of neck constriction and, evidently, a slight rim eversion.

The Vinette 1 (or Vinette Interior Cordmarked of Smith, 1950, p. 195), North Beach Brushed and Matinecock Point Stamped types are assigned by Smith to the North Beach Focus of the early Intermediate period,[38] equivalent to the Early Woodland period, as now preferred by the writer. On typological and stratigraphic grounds, the presumed new type, Stony Brook Corded, may be referred to the same temporal horizon. These types, therefore, would seem to comprise a consistent early group which at Stony Brook makes its appearance during the period of accumulation of the upper portion of Midden A. It would, therefore, appear that during the earlier period of occupation by people of the Orient culture, when the lower portion of Midden A was being laid down, the Orient culture may have been as preceramic as its evident predecessor, represented by Midden B. These new data accord with the testimony afforded by the Orient burial sites, and they also sustain, in part, Smith's postulated concurrence of North Beach and Orient.[39] The total data regarding Orient do not, however,

[38] Smith, 1950, pp. 107, 195, 196.
[39] Ibid., p. 107.

support his contention that Orient is merely the mortuary manifestation of the North Beach Focus.[40] To this matter we shall later return.

The Sebonac Stamped sherds, if correctly identified, would belong, according to Smith,[41] to the Late Prehistoric (= Late Woodland) period, and their presence at Stony Brook would suggest either the persistence of the Orient to this time, or much more likely, a subsequent brief use of the site by a later cultural group, possibly to be regarded as ancestral to the historic Algonkian Setauket tribe of this locality.

TABLE 1.

Inventory and Distribution of Artifacts

	SECTION	LOCATION	DEPTH IN INCHES	CAT. NO.	ILLUSTRATION
			Chipped Stone		
Projectile Points					
Orient Fishtail	E10N5	Topsoil	1½	41479-7	Pl. 20, fig. 11
	E10N25	Topsoil	2	41713-1	Pl. 20, fig. 34
	W5N0	Topsoil	3½	41697-2	Pl. 20, fig. 6
	E0N0	Topsoil	4	41463	Pl. 20, fig. 30
	E0N10	Topsoil	5	41470-1	Pl. 20, fig. 32
	W5N5	Topsoil	6	41698-2	Pl. 20, fig. 4
	E35N25	Midden A	3	41721-1	Pl. 20, fig. 24
	E10N5	Midden A	3	41691-2	Pl. 20, fig. 21
	E50N20	Midden A	3	41732-1	Pl. 20, fig. 26
	E40N40	Midden A	4	41726-1	Pl. 20, fig. 33
	W10N10	Midden A	4	41692-1	Pl. 20, fig. 9
	E10N5	Midden A	5	41479-1	
	E10N5	Midden A	5	41479-2	Pl. 20, fig. 13
	W10N5	Midden A	5	41691-7	
	W10N5	Midden A	5	41691-8	Pl. 20, fig. 18
	E10N0	Midden A	5½	41477-1	Pl. 20, fig. 25
	E15N30	Midden A	6	41717-6	
	W10N5	Midden A	7	41691-12	Pl. 20, fig. 2
	E5N5	Midden A	7	41473-1	Pl. 23, fig. 7
	E15N15	Midden A	7	41715-2	
	E10N0	Midden A	7	41477-3	
	E0N15	Midden A	7	41704-1	Pl. 20, fig. 29
	E10N25	Midden A	7	41713-2	
	E10N0	Midden A	7½	41477-4	
	W10N0	Midden A	8	41690-8	Pl. 20, fig. 31
	E0N20	Midden A	8	41705-1	Pl. 20, fig. 15
	E0N15	Midden A	8	41704-2	Pl. 20, fig. 23
	E55N20	Midden A	8	41735-3	

[40] Ibid., p. 150.
[41] Ibid., pp. 107, 194.

TABLE 1 (*Continued*)

Inventory and Distribution of Artifacts

	SECTION	LOCATION	DEPTH IN INCHES	CAT. NO.	ILLUSTRATION
Orient Fishtail (continued)	E15N25	Midden A	8½	41716-1	Pl. 20, fig. 7
	E15N25	Midden A	8½	41716-2	Pl. 20, fig. 20
	E5N10	Midden A	9	41475-4	Pl. 20, fig. 27
	E10N25	Midden A	10	41713-4	
	E15N25	Midden A	10	41716-3	
	E15N30	Midden A	10	41717-3	Pl. 20, fig. 16
	E15N25	Midden A	10½	41716-4	
	E40N25	Midden A	12	41723-2	
	E40N30	Midden A	12½	41724	
	E0N10	Midden A	13	41470-2	Pl. 20, fig. 22
	E65N25	Midden B	12	41740-4	Pl. 20, fig. 10
	E35N20	Midden B	12	41720-2	Pl. 20, fig. 28
	W15N15	Midden B	17	41687-2	
	E45N25	Midden B	23½	41728-5	Pl. 20, fig. 12
	E0N5	Pit 1, Fea. 2	11	41466-1	Pl. 20, fig. 19
	E0N5	Pit 1, Fea. 2	18½	41466-3	Pl. 20, fig. 5
	E0N5	Pit 1, Fea. 2	20	41466-4	Pl. 20, fig. 8
	E5N10	Pit 1, Fea. 2	22	41475-9	Pl. 20, fig. 1
	E0N5	Pit 1,Fea. 2	34	41466-6	Pl. 20, fig. 3
	E25N5	Pit 3, Fea. 4	9½	41487-1	Pl. 20, fig. 14
	E20N0	Pit 2, Fea. 3	12-13	41483-4	Pl. 20, fig. 17
	E40N35	Pit 5, Fea. 6	42	41725-11	
Stemmed and Side-notched narrow,					
stemmed	W10N5	Topsoil	2	41691-1	Pl. 21, fig. 5
small, narrow, side-notched	W10N0	Topsoil	3½	41690-2	Pl. 21, fig. 9
broad, side-notched	W10N0	Topsoil	3½	41690-4	Pl. 21, fig. 15
small, side-notched	E5N15	Topsoil	4	41708-1	Pl. 21, fig. 10
small, narrow, stemmed	E55N20	Midden A	4	41735-1	Pl. 21, fig. 3
broad, side-notched	E45N30	Midden A	7	41729-3	Pl. 21, fig. 6
small, narrow, stemmed	E15N30	Midden A	7	41717-1	Pl. 21, fig. 2
(?) side-notched	E5N25	Midden A	7½	41710-1	
broad, side-notched (?)	W5N25	Midden A	7½	41702-4	
broad,					

TABLE 1 (*Continued*)

Inventory and Distribution of Artifacts

	SECTION	LOCATION	DEPTH IN INCHES	CAT. NO.	ILLUSTRATION
Stemmed and Side-notched (*cont.*)					
side-notched broad,	E20N25	Midden A	7½	41718-2	Pl. 21, fig. 25
stemmed small, narrow,	E15N30	Midden A	11	41717-4	
side-notched broad,	E40N25	Midden A	11½	41723-1	Pl. 21, fig. 12
stemmed small, narrow,	E40N20	Midden B	6	41722-1	Pl. 21, fig. 32
side-notched small,	E45N20	Midden B	8½	41727-3	Pl. 21, fig. 20
stemmed broad,	E65N25	Midden B	9	41740-3	Pl. 21, fig. 11
side-notched small, narrow,	E45N20	Midden B	9	41727-4	Pl. 21, fig. 13
side-notched broad,	E0N20	Midden B	10	41705-2	Pl. 21, fig.21
stemmed broad,	W5N5	Midden B	10	41696-2	Pl. 21, fig. 33
stemmed broad,	E35N25	Midden B	10½	41721-2	Pl. 21, fig. 37
stemmed broad,	E35N20	Midden B	11	41720-1	Pl. 21, fig. 35
side-notched small, narrow,	E40N20	Midden B	11	41722-4	Pl. 21, fig. 27
side-notched narrow,	E45N25	Midden B	12	41728-3	Pl. 21, fig. 8
side-notched broad,	E10N30	Midden B	12	41714-1	Pl. 21, fig. 18
stemmed narrow,	E40N25	Midden B	12	41723-3	Pl. 21, fig. 36
side-notched narrow,	E60N20	Midden B	12	41738A-1	
stemmed broad,	W5N20	Midden B	12½	41701-3	Pl. 21, fig. 4
stemmed broad,	E0N25	Midden B	13	41706-1	Pl. 21, fig. 30
stemmed broad,	E35N25	Midden B	13	41721-3	Pl. 21, fig. 29
stemmed broad,	W10N15	Midden B	14	41693-2	Pl. 21, fig. 34
side-notched broad,	W15N10	Midden B	14	41687-1	Pl. 21, fig. 23

TABLE 1 (*Continued*)

Inventory and Distribution of Artifacts

	SECTION	LOCATION	DEPTH IN INCHES	CAT. NO.	ILLUSTRATION
Stemmed and Side-notched (*cont.*)					
side-notched broad,	E5N25	Midden B	15	41710-4	Pl. 21, fig. 26
side-notched small, narrow,	E45N40	Midden B	15	41731-2	Pl. 21, fig. 22
stemmed broad,	E55N30	Midden B	18	41737-1	Pl. 21, fig. 1
side-notched narrow,	W10N10	Midden B	19	41692-3	Pl. 21, fig. 14
side-notched broad,	E40N25	Midden B	21	41723-6	Pl. 21, fig. 19
side-notched broad,	E10N25	Midden B	24	41713-5	Pl. 21, fig. 24
side-notched small, narrow,	W5N15	Midden B	25	41700-3	Pl. 21, fig. 28
stemmed narrow,	E5N10	Subsoil	29	41475-10	
stemmed (?) small, narrow,	E5N10	Pit 1, Fea. 2	20	41475-8	
side-notched broad,	E20N0	Pit 2, Fea. 3	8	41483-2	Pl. 21, fig. 7
side-notched broad,	E25N25	Pit 3, Fea. 4	19	41487-2	Pl. 21, fig. 17
side-notched broad,	E40N35	Pit 5, Fea. 6	22	41725-9	Pl. 21, fig. 16
stemmed lozenge-shaped	E40N35	Pit 5, Fea. 6	40	41725-10	Pl. 21, fig. 31
lozenge-shaped	E0N30	Midden A	5	41707-3	Pl. 22, fig. 19
lobate-stemmed	E45N40	Midden A	5	41731-1	Pl. 22, fig. 20
lobate-stemmed	E5N10	Midden A	8	41475-3	Pl. 22, fig. 4
Triangular broad,	E40N40	Pit 5, Fea. 6	13	41725-18	Pl. 22, fig. 5
equilateral broad,	E0N30	Midden A	2	41707-1	Pl. 22, fig. 12
equilateral narrow	W5N0	Midden A	6½	41697-5	Pl. 22, fig. 13
isosceles narrow,	E45N20	Midden A	4½	41727-1	Pl. 22, fig. 11
isosceles	E45N25	Midden A	11	41728-2	Pl. 22, fig. 6

TABLE 1 (*Continued*)

Inventory and Distribution of Artifacts

	SECTION	LOCATION	DEPTH IN INCHES	CAT. NO.	ILLUSTRATION
Ovate or Trianguloid Knives					
	E10N0	Midden A	7	41477-2	Pl. 22, fig. 26
	E55N20	Midden A	7½	41735-2	Pl. 22, fig. 22
	W15N15	Midden A	11	41688-1	Pl. 22, fig. 23
	E45N20	Midden B	8	41727-2	Pl. 22, fig. 24
	E45N20	Midden B	11	41727-5	Pl. 22, fig. 25
	E60N25	Midden B	11	41739-2	
	E45N30	Midden B	14	41729-4	Pl. 22, fig. 21
Drills					
	E15N15	Midden A	6	41715-8	Pl. 22, fig. 16
	E5N10	Midden A	13	41475-7	Pl. 22, fig. 14
	W5N20	Midden B	12½	41701-2	Pl. 22, fig. 15
	W5N30	Subsoil	26	41703-2	Pl. 22, fig. 17
Scraper (?)	W5N25	Topsoil	4	41702-1	Pl. 22, fig. 18
		Rough Stone			
Hammerstones	E0N15	Midden A	.....	41704-4	Pl. 23, fig. 14
	W10N25	Midden A	.....	41695-2a	Pl. 23, fig. 15
	(Test pit, 20 ft. south of E0N0)	Midden A	7	41489	Pl. 23, fig. 19
Anvilstone	W10N25	Midden A	.....	41695-2b	Pl. 23, fig. 18
Rude celt (?)	W5N25	Midden B	10	41702-5	Pl. 23, fig. 16
Paint stones					
(hematite)	E10N0	Midden A	8	41478-2	Pl. 22, fig. 29
hematite	E25N5	Pit 3, Fea. 4	20¼	41488	Pl. 22, fig. 30
graphite	E40N20	Midden A	10½	41722-3	Pl. 22, fig. 27
Stone potsherds	W10N10	Midden A	8	41692-2	Pl. 23, fig. 17
	W5N10	Midden A	11	41699-1	Pl. 23, fig. 17
		Bone			
Awls	E0N5	Topsoil	8	41467	
	E40N20	Midden A	9	41722-2	Pl. 22, fig. 2
	E0N10	Midden A	12	41471	Pl. 22, fig. 9
	E40N20	Midden A	12	41722-5	
	E45N20	Midden A over Hearth 2, Fea. 7	5½	41728-1	Pl. 22, fig. 1
	E20N30	Midden B	12	41719-1	Pl. 22, fig. 8
	E10N30	Midden B	15	41714-3a	Pl. 22, fig. 7
Flaker (?)	W10N5	Midden A	9	41691-19	Pl. 22, fig. 3

TABLE 1 (*Concluded*)

Inventory and Distribution of Artifacts

	SECTION	LOCATION	DEPTH IN INCHES	CAT. NO.	ILLUSTRATION
		Shell			
Bead	E20N25	Midden A	6½	41718-1	Pl. 22, fig. 10
		Pottery			
Stony Brook Corded	W5N0	Topsoil	2, 8	41697-1, 8	
	W5N5	Midden A	8	41698	Pl. 24, figs. 10, 14
	E50N20	Midden A	10, 13	41732-3-5	
	E15N30	Midden A	11½	41717-5	
	E20N30	Midden B	25	41719-3	Pl. 24, fig. 9
	W10N5	Pit 4, Fea. 5	9	41474	
North Beach Brushed (?)	W15N15	Midden A	4	41686-1	
	W10N0	Midden A	5	41690-1	Pl. 24, fig. 13
	W15N5	Midden A	10	41686-1	Pl. 24, fig. 12
	E45N30	Between Middens A, B	7	41729-1, 2	Pl. 24, fig. 11
	W10N5	Pit 4, Fea. 5	3, 8½	41691-3, 18	
Vinette I (?)	E55N25	Midden A	4	41736-1	Pl. 24, fig. 8
Matinecock Point Stamped (?)	E0N30	Midden A	5	41707-2	Pl. 24, fig. 5
	W5N30	Midden A	7	41703-1	
	E60N25	Midden A	7	41739-1	
	E65N25	Midden A	7	41740-2	
	E0N5	Pit 1, A complex	9, 12, 17	41465-1, 3	Pl. 24, figs. 6, 7
Sebonac Stamped (?)	W10N5	Midden A	4-8	41691	Pl. 24, fig. 1
	E50N20	Midden A	8	41732-2	Pl. 24, fig. 4
	W10N5	Midden A	10	41725-17	Pl. 24, fig. 2
	E5N15	Midden A	17	41708-2	Pl. 24, fig. 3

FOOD REMAINS

The Stony Brook site contributes significantly to knowledge of coastal New York archeology because it tells us how the people of the Orient culture made a living. Prior to this work it was by no means sure that the Orient culture was not a mortuary manifestation of some unknown Connecticut people who periodically crossed the Sound to bury their dead with particular ceremonies on certain prominent eastern Long Island hilltops.[42]

[42] Ritchie, 1944, p. 232.

Another hypothesis related the Orient burial sites to the North Beach Focus on Long Island.[43] We can now assert with confidence that these cemeteries relate to an Orient cultural group, former inhabitants of the Island, and that their manner of life did not essentially differ from their predecessors (as at Wading River) and their successors, who persisted down to historic times.

Samples of charcoal taken from Stony Brook and three of the four Orient cemeteries have now been dated by the Carbon-14 method, enabling us, for the first time, to establish the temporal relationships among these sites (see pages 47-49, 74-76), and to show the contemporaneity of Stony Brook and Orient No. 2.

Several problems, however, remain to be solved. First among them is the house type and settlement pattern of the Orient culture. Most unfortunately, our careful search at Stony Brook disclosed but one possible post mold, having a diameter of 3 inches, a depth of 11 inches, and a pointed base, in the subsoil under Midden A, in section W5N0. It would seem that housing consisted of flimsy, temporary shelters, possibly of light poles and mats. Further, that these huts were scattered around over the site, to become surrounded by the accumulating midden debris.

This debris, as preserved in Midden A, is richest in shellfish detritus, which comprises an estimated 65 percent of its volume. The shell refuse consists of the crushed or intact valves of the following species, listed in descending order of abundance: oyster (*Ostrea virginica*), bay scallop (*Pecten irradians*), hard-shelled clam (*Venus mercenaria*), soft-shelled clam (*Mya arenaria*), a gastropod of the genus *Littorina* (commonly called a periwinkle), channeled whelk (*Busycon canaliculatum*), and ark (*Arca* sp.?).

A thin scattering of mammal, bird and reptile bones occurred among the shells, occasionally in small concentrations, suggesting the discards of a single meal. Nearly all were broken into little pieces, presumably for the most part, to secure the marrow and brains, hence their identification presented some difficulty.[44] It was, however, certain that the great majority were derived from the Virginia deer (*Odocoileus virginianus*), that many of the bird bones represented the wild turkey (*Meleagris gallopavo*), and that the common box turtle (*Terrapene carolina*) was extensively eaten. Other recognizable species were the following: woodchuck (*Marmota monax*), raccoon (*Procyon lotor*), gray fox (*Urocyon cinereoargenteus*), mink (*Mustela vison*) and Indian dog (*Canis familiaris*). In addition, various small rodents, perhaps squirrels, and ducks were represented.

[43] Smith, 1950, p. 150.

[44] The assistance in this task of Dr. Edgar M. Reilly, Curator of Zoology, New York State Museum, is gratefully acknowledged.

The absence of fish remains and fishing gear of any kind is noteworthy. The picture, as presented by the evidence at hand, portrays for the Orient people, responsible for Midden A and the pits, a primary dependence upon shellfish gathering; supplemented by hunting of the deer and smaller mammals, the turkey, waterfowl and smaller birds, and the "collecting" of land turtles and such vegetable foods as hickory nuts.

There is no evidence of the use of stone grinding devices for the preparation of acorn or other meal, although it is possible that wooden mortars and pestles may have been employed for this purpose; nor is there the smallest hint of a knowledge of agriculture.[45] Stone-boiling in perishable vessels and baking on heated stones in pits or open hearths are amply attested, as is boiling in stone vessels and, to a limited extent, in pottery receptacles. Considered in connection with the data afforded by the burial sites, knowledge and use of pottery came late in the history of this culture.

In all probability snares and deadfalls formed a part of the hunting equipment, although we can prove only the use of stone projectile points. From the size and weight of these points, prevailingly of fishtail type, and the discovery of two forms of the bannerstone in the Orient cemeteries, we may infer that the hunting weapon was the javelin or spear projected with the throwing stick or atlatl, rather than the bow and arrow.

Additional attempts at the reconstruction of the culture will accompany consideration of the burial customs.

If we attribute the deeper Midden B to a pre-Orient group of people, culturally affiliated with the Laurentian tradition, we may deduce from the food remains of this midden a heavier reliance on hunting than on shellfish gathering, for deer bones were relatively far more common in this level than valves of the oyster, hard clam and scallop. At one locus in the northeast quadrant of section E40N40, 14 inches below the surface, a concentration of small fragments of deer bone, measuring approximately 15 inches in diameter and 3 inches thick, suggested the residue of bone-grease manufacture.[46] Shattered bits of the carapace of the box turtle and various bird bones also occurred throughout Midden B.

AGE OF THE STONY BROOK SITE

Throughout the excavation of the Stony Brook site constant close attention was given the search for suitable organic substances for radiocarbon dating. Among these, of course, shell refuse vastly predominated, with animal bones and wood charcoal following in greatly decreasing frequency.

[45] Rude elongate stone pestles have been found on some of the burial sites (see p. 51).

[46] Leechman, 1951, pp. 355-356.

While many samples of shells and refuse bones were collected, it was decided to submit for Carbon-14 measurement only the charcoal, since highly unreliable results have been experienced in dating marine shells, due to the fact that these mollusks may have built into their shells not only contemporaneous carbon but also ancient carbon derived from calcareous waters carrying carbon, dissolved from ancient rocks.[47] While use has been made both of carbonized and unburned bone in radiocarbon dating, wood charcoal continues to hold a preferred place among radiocarbon-datable media.

Unfortunately, discrete particles of charcoal, while recovered from several hearths and pits, were not only very small in size and thus hard to collect, but the quantities obtainable proved in most cases inadequate for reliable measurements, as currently required. The major exception was the approximately 68 grams collected from the lowest 10 inches of Pit 5, Feature 6, where it occurred intermixed with fire-shattered rocks in dry, virtually root-free sand, at 40 to 50 inches below the surface. (See page 26 and plates 11-13.) This subsequently became sample M-588 of the University of Michigan.

The second exception comprised about 16 grams of clean wood charcoal, secured from the southern half of section W5N15, at depths ranging between 22 and 26 inches from the surface. This material occurred scattered in tan or gray sand of what appeared to be Midden B, along with sparsely distributed shells, refuse bone, quartz chips and burned stones. The midden soil at this particular locus, however, differed from that generally characteristic of Midden B in producing a relatively larger quantity of these industrial wastes, and also in having a high gray ash and charcoal content, suggesting, on the whole, that this particular portion of the midden represented the scattered contents of a hearth. No artifacts were present in direct association, but a broad side-notched point (41700-3) came from a depth of 25 inches in the southwest corner of the same section (see plate 21, figure 28). It was anticipated that this sample (M-587) might date the postulated older level of occupation at the site, an assumption not justified by the results.

The samples were submitted for Carbon-14 measurement to Professor H. R. Crane, director of the University of Michigan Memorial-Phoenix Project Radiocarbon Laboratory, who has reported for M-587 an antiquity of 2,900 $\pm$ 250 years, for M-588 an age of 2,930 $\pm$ 250 years.

This indicated near contemporaneity of the samples imposes the problem of whether middens of two ages actually exist at Stony Brook; whether the material of M-587 was somehow intruded deeply from Midden A,

[47] Flint, 1956, p. 278.

which might account for the observed concentration of refuse at this locus, or whether both samples might pertain to the Midden B horizon. The quandary cannot easily be resolved. I shall, however, reaffirm my impression, based upon stratigraphy, soil character and, especially, typology, that essentially two habitation levels were represented at the site.

The temporal difference between them may not have been large, indeed, it may have been so slight as to be contained in the plus or minus variations of the given dates. There exists evidence from other sources to suggest the partial temporal overlap in eastern and coastal New York of Laurentian and Orient manifestations.[48]

Finally, the remarkable congruence, amounting in one case to identity, within the series of dates comprising those from Stony Brook and from certain of the Orient cemeteries, now to be considered, greatly strengthens the assumption from the cultural evidence of an intrinsic relationship between the Orient habitation level at Stony Brook and the burial sites.

Orient Burial Sites

ALL FOUR KNOWN SITES of this kind are located on eastern Long Island, three on the north or Orient fork, one on the South or Montauk fork. They are strictly burial components without known associated habitation areas. Indeed, almost the only definitely established settlement locus is the Stony Brook site.[49] Between 1935 and 1941 these sites were found and excavated by members of the Long Island Chapter, New York State Archeological Association, most of the work having been done by Roy Latham of Orient. As Mr. Latham has in preparation a report covering this work, I shall give only a concise description, based upon data previously supplied by him and supplemented by personal studies of the material unearthed, made through the courtesy of Mr. Latham and the late Charles F. Goddard of Mattituck, former chapter president and active

[48] Ritchie, 1958, pp. 68, 70-71, 100. The lower level of one of these eastern New York Laurentian sites (the Bannerman site in the Hudson Valley) has, however, been radiocarbon dated to 2524 B. C. ± 300 years (Ibid., p. 67).

[49] Latham mentions a possible habitation locus of this culture on the shore of Peconic Bay, near Greenport, only a few miles from Orient sites numbers 1 and 2 (Latham, 1953, p. 109). The Muskeeta Cove site, at the western end of the island, has already been referred to (Patterson, n.d.). However, as Latham has observed (op. cit., p. 110), the fishtail form of point has a wide surface distribution on Long Island. Reference has already been made to finds of this kind on the high land adjacent to the Wading River site, and an additional locus was investigated by the State Museum and Science Service in 1953 on the John Robert farm, on Moriches Bay, near East Moriches. At neither of these places has it been possible to isolate an Orient culture component, and this seems to be equally true of the other reported instances of surface-distributed Orient Fishtail points.

participant in the site investigations.[50] This brief account will then be augmented by the results of the recent excavations of the State Museum and Science Service on two of these burial stations, viz., Jamesport and Sugar Loaf Hill.

The Orient burial components are situated on prominent sandy knolls visible either from Long Island Sound or from some other major embayment of the sea, and in no case are they far from access by water. At Jamesport, the major portion of a restricted hilltop was occupied by a large, oval burial pit; at Orient No. 2 and Sugar Loaf Hill there were, in addition to the large central pit, smaller peripheral ones; while at Orient No. 1 only a cluster of small burial pits was reported. The major pits are said to have approximated 30 feet in length, 18-23 feet in breadth, and 5-8½ feet in maximum depth. The smaller, apparently individual burial pits, measured some 6 feet in diameter by 3-8 feet in depth.

The upper fill is described as a clean sand, the lower portion of the pit as consisting of sand stained with charcoal and perhaps other organic contents. The principal features of the large structures are referred to as "hearths" or fireplaces, some outlined with stones and containing much charcoal, occasionally a little burned stone and calcined bone, some identifiable as human; deposits of red ocher, also sometimes associated with calcined bone fragments, and "caches" or aggregations of artifacts, presumably offerings of grave goods, which occur in marked concentrations or somewhat scattered, not only in the immediate vicinity of the hearths and ocher masses, but elsewhere upon the pit floor.

The small pits produced similar assemblages of artifacts at their bottoms. No mention of burned bones is made for these, but the single uncremated burial reported for any of these sites occurred on the Orient No. 2 site as a much decayed mass of long bones, rib and skull fragments, suggesting a bundle interment, at the bottom of an 8-foot shaft. Charcoal granules, red paint and artifacts, including a steatite potsherd which fitted a fragment from the large burial pit, were found near the human remains.

The artifact inventory, closely duplicated from site to site, while rather narrowly limited in variety, is of much interest in disclosing the cultural status and connections of the Orient people, whose intensive participation in an early mortuary ritualism, recently described by the writer,[51] is also in part revealed by the selection of and treatment accorded certain of these offerings. In still larger part it is, of course, dependent upon the character and features of the sites themselves.

Quantitatively, projectile points of the Orient Fishtail type and stone vessels of a wide range of shapes and sizes, both represented in Midden A

[50] For a fuller account from which this is abstracted, see Ritchie, 1944, pp. 227-235.
[51] Ritchie, 1955.

at Stony Brook, head the list of burial goods at all four sites. Also present in varying numbers at one or more of the sites are narrow-bladed, stemmed or side-notched points; relatively broad, side- or corner-notched points; drills with stemmed, expanded or side-notched bases; rude cylindrical pestles; pebble hammerstones with beveled edges; rectangular celts and plano-convex adzes, some of the latter grooved; fully grooved axes; short gouges; grooved and winged, or tubular perforated bannerstones; polished stone gorgets of ellipsoidal, broad or narrow rectangular forms, frequently bearing rude engravings; paintstones of hematite and graphite; fire-making sets comprising pyrites (decayed to limonite) and quartz strikers, and a very small quantity of pottery.[52]

No bone, shell or copper artifacts have been found, but only the latter would have been preserved, due to the acidity of the native sand.[53] The possible use of turtle shell rattles is inferred from the finding in several places of heaps of small quartz pebbles. Also, a fragmentary antler flaker has provisionally been identified among our calcined bone remains from the Jamesport site (see plate 30, figure 5).

Sherds of pottery vessels, found both by the previous investigators and our parties at Jamesport and Sugar Loaf Hill, have a particular bearing upon the age and associations of the Orient culture. No pottery was found at Orient Nos. 1 and 2, and but one vessel is reported from Jamesport. Partially restored by Mr. Latham, it depicts a long, oval, rather trough-shaped receptacle, probably with a rounded bottom, and has a transverse bar lug at the preserved end. As remarked by Mr. Latham, it represents "a precise copy, in ceramic, of the soapstone vessels in that site."[54] Four additional sherds found by us between depths of 9 and 49 inches on this site may pertain to the same pot (plate 31, figure 1; plate 33, figures 9-11). At least three of them conform in all respects with the sherds submitted by Mr. Latham for study by the writer (see plate 34, figure 2; plate 35, figure 4). The fourth (plate 33, figure 9), although of similar paste, has been rudely smoothed on both surfaces and is nearly flat.

Mr. Latham reports the finding of two pots at Sugar Loaf Hill, which he says "are of later type, high straight-sided pots with rounded bases."[55] One of these partially restored pots, on display, like most of the Orient burial site collections, at the Suffolk County Historical Society Museum in Riverhead, Long Island, has a round oral, about 8 inches in diameter, lacks the base and has straight-sided walls some 10 inches in height (repre-

[52] Most of these traits are illustrated in this report or in Ritchie, 1944, Plates 107, 108.

[53] Results of soil tests for the Jamesport and Sugar Loaf Hill sites are given below.

[54] Latham, 1953, p. 109.

[55] Ibid., p. 110.

senting approximately two-thirds of the original) and a narrow rounded lip. A possible sherd of this pot, recovered in our excavation at Sugar Loaf Hill in 1956, is pictured on plate 46, figure 25.

Several portions of the second Sugar Loaf Hill pot, sent by Mr. Latham for study, are shown on plate 34, figures 1, 3; plate 35, figures 1-3. They seem not to have come from a round vessel like the first, but rather from an elongate, oval pot, generally similar to the Jamesport vessel which copies a stone receptacle. A more detailed description of the total ceramic content of the two sites will be given in a subsequent section of this report.

JAMESPORT SITE (RIH 1-2)

The Jamesport site lies approximately one-fifth of a mile northwest of the intersection of Route 25 and Manor Lane, Jamesport, Suffolk County. It is nearly one mile in the same direction from the nearest shore of Great Peconic Bay, which can be seen, when the trees are not in leaf, from the highest point on the hill, where the burial pit was located. Mrs. Mary Sieminski, owner of the farm, kindly gave permission for our excavations of September 28-October 7, 1953, the work being done by the writer assisted by Professor Irving Rouse of Yale University and Peter P. Pratt.[56]

The site covers most of the southern and highest elevation of an oval rise or knoll belonging to the Harbor Hill Ridge[57] and is approximately 50 feet above sea level and 30 feet higher than the surrounding land (plate 25).

This was the last Orient burial site to be found and excavated (1940-41) by the Long Island Chapter, New York State Archeological Association. According to reports of the excavators, it comprised a big oval pit, measuring some 30 by 18 feet, the long axis running nearly east and west, with a maximum depth of 8½ feet. On the floor near the eastern end was uncovered a circle, about 5 feet in diameter, of vertically set large stone slabs approximately 3 inches in thickness. This structure enclosed a hearth containing, among the charcoal fragments, burned human bones and a deposit of artifacts consisting of many projectile points, several paintstones and portions of at least two stone pots. Elsewhere over the pit floor were found similar, but unenclosed, hearths and caches of implements, some in association with masses of powdered red ocher and decomposed iron pyrites.

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[56] Valuable volunteer aid, especially with survey and mapping, was given by John H. Husing of the Long Island Chapter, New York State Archeological Association. Thanks are also due to Mrs. Dorothy Raynor, of the same chapter, for various courtesies, and to Douglas S. Byers of Phillips Academy, Andover, Mass., for assistance on a weekend visit to the site.

[57] Fleming, 1935.

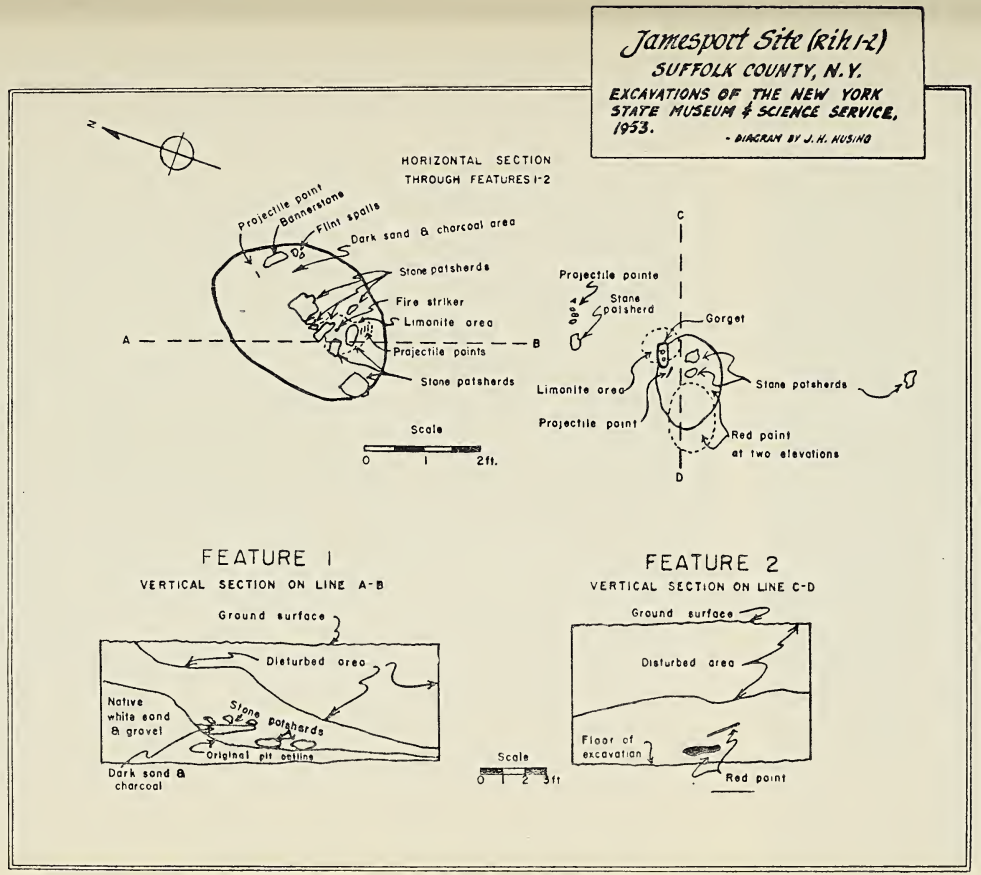

Figure 5. Horizontal and vertical sections of Features 1 and 2, Jamesport site

The State Museum and Science Service sought at this site possible additional clues to the nature of the unique Orient burial pits and the aboriginal activities which took place there, as well as for samples of charcoal to assist in dating the Orient complex. It is the writer's belief that the Orient mortuary practices were complex and were intrinsically related to an Early Woodland period burial cult in the Northeast, which formed part of a rather widely disseminated religious movement in the eastern United States during this period. In subsequent developments, this cult, or more or less formalized system of religious concepts and rites devoted to the welfare of the dead, is thought to have attained its climax in the Adena-Hopewellian manifestations of Middle Woodland times.[58]

Feature 1

The labors of the party were rewarded in the western section of the burial pit by the discovery of two features at well-separated loci, lying at levels below those reached in the primary investigations. Moreover, a quantity of charcoal obtained from Feature 1 has yielded a Carbon-14 dating for the site. These features occurred at or near the bottom of the original pit, a small segment of whose northwestern wall-floor outlines could be traced in our excavations beneath and slightly beyond the limits of the overriding disturbance of 1940-41, as may be seen in plate 26 and figure 5.

The aboriginal pit had been dug into a well-drained, fine to medium coarse white sand and quartz gravel, of a bright, clean and striking appearance. To the Indians, seeking a suitable burial place for their collected dead, these qualities may have had a similar appeal which, added to the general mound-like elevation high above all the surrounding terrain and within sight of the great bay, may have led to its selection. Very likely other indeterminable factors, both cultural and physical, were also involved.

The pit wall sloped less steeply than we would have anticipated and the arc at the western end indicated a distinctly oval structure, as described by the previous excavators. A close watch for post molds or evidence of a habitation floor revealed nothing, but several dark stains along the shoulder of the pit suggested the possibility of a partial lining of organic substance, such as bark, wood or matting. Samples of this material show, under the microscope, particles resembling wood charcoal and, as such occurred in larger quantity and fragment size in the adjacent "hearth" area, they may represent only lateral extensions thereof.

The fill of the original pit could clearly be differentiated by its yellowish or tan coloration, both from the native white sand and from the humus-spotted and otherwise darker sand of the 1940-41 disturbed overlying fill

[58] Ritchie, 1955, pp. 67-76.

(plate 26 and figure 5). Moreover, throughout the tan sand covering most of the area of Feature 1, scattered charcoal granules were observed. As the feature was approached, the amount of charcoal in the sand rapidly increased to form a hearth-like concentration with a maximum diameter of about 33 inches and up to 4 or 5 inches in thickness, largely overlying the artifacts to be described and extending on the north to the pit edge (see figure 5). This mass of stained sand and discrete wood charcoal particles, the largest pieces approximately one-fourth of an inch in length, was the principal source of the sample secured for dating purposes. To it were added some charcoal bits taken from the less concentrated scatter directly over the feature. The results of the Carbon-14 assay are reported on page 75.

Although referred to in our notes as a "hearth," this element of Feature 1 presented no convincing token of a fire kindled *in situ* in the pit. There was neither ash nor surrounding soil discoloration resulting from thermal effects. Furthermore, the wide dispersion of charcoal flecks through some 20 inches of overlying sand, and the occurrence within this superincumbent zone of apparently randomly dispersed artifacts and calcined animal bones, heighten the probability that the residue of a fire and of burned food remains were brought into the pit and intentionally scattered, together with several projectile points, stone pot fragments and a hammerstone (plate 30, figures 7-9) over the feature placed upon the floor, during the initial filling of this part of the structure. This observation was repeated in our 1956 excavation at the Sugar Loaf Hill site, presently to be described. It calls into question the validity of the identification as "hearths" of apparently similar features mentioned for all four Orient burial sites. It also has distinct parallels in certain graves of the Early Point Peninsula complex on the Indian River sites in Jefferson County, N. Y., which share the basic features of the mortuary cult, as defined by the writer.[59]

Of the 54 fragments of calcined bone mentioned as apparently associated with Feature 1, four are identifiable as deer phalanges, an equal number as representing birds of medium size, seven are of antler (one seems to be part of a tine flaking tool), one may be from the head of a radius and has human shape and size, while the remainder are long bone scraps (see plate 30, figures 1-6).

It is suggested that these osseous remains pertain to animal food consumed, perhaps with other perishable offerings to the deceased, in a funeral fire in the vicinity of the pit, and subsequently poured, as part of the mortuary ritual, over the interred contents of the feature. That the burning of animal food, dogs and artifacts figured in the rites of the mortuary

[59] Ritchie, 1955, pp. 15, 17, 28, 30-31, 32, 62-63, 64-65.

cult under consideration is attested by the writer's discoveries on other sites of this category, elsewhere described.[60]

Since calcined bone pieces in the Orient pits are apparently confined to the vicinity of the "hearths" and their associated "caches" of artifacts, it is improbable that the fortuitous inclusion of habitation refuse can be invoked in explanation, especially in view of the local absence of such habitation components.

The discovery of burned animal bone in Feature 1 raises the question of the valid identification as human cremations, at least in all cases, of calcined bone fragments found in these sites in association with the "hearths" and "caches." It is clear, however, from positive determinations of certain of these remains previously submitted by Mr. Latham to the writer, that cremated human bone was present at least on the Orient No. 2 component, and there seems little reason for doubt, on the other sites as well. But that all the calcined bone found on these sites derives from human cremations, as has been assumed, is certainly in error. The cremation of dog bones was a significant element of the burial ritualism involved here.[61]

The artifact contents of Feature 1 occurred within an oval area of stained sand, measuring about 3¼ by 2¼ feet, and for the most part they rested directly upon the virgin white sand floor of the pit, at depths ranging between 44 and 51 inches from the present surface. As illustrated in plates 26, 27, 29, 30 and figure 5, they constituted a loose cluster comprising 5 broken stone pots, 7 projectile points of fishtail form, a fire-making set consisting of a mass of decomposed iron pyrites (altered to limonite) and a quartz striker made from a point, a winged and grooved bannerstone and 2 rough core fragments of brown flint.

All the pots save one were intentionally broken, portions of two being missing, one of several facts suggesting breakage beyond the immediate precincts of the feature. In the exceptional case (plate 29, figure 1), the worn old break line and drilled lacing hole indicate the inclusion of half an accidentally broken and still-used vessel. Of very considerable significance, in linking together this group of artifacts with the scattered charcoal, burned animal bones and random projectile points found overlying the group of artifacts, between about 29 and 35 inches from the surface, were the sherds of a small stone bowl with notched lip decoration (plate 29, figure 2), which were scattered throughout the feature from 29 to 57 inches deep. It seems, therefore, unequivocal that the entire deposit of charcoal-stained sand, burned bones and artifacts, comprising Feature 1, represents a single episode.

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[60] Ritchie, 1944, pp. 156, 158; 1955.
[61] Ritchie, 1944, pp. 150, 152 ff.; 1955, p. 62.

In considering the nature of this episode, I believe it can reliably be inferred from the total evidence afforded by the four Orient mortuary components, supplemented by data from other sites, particularly those on the Indian River of northern New York,[62] that a noncremated human burial was interred at this locus as the primary element of Feature 1. It is impossible to infer exactly the mode of burial, since either a tightly flexed skeleton or a bundle of disarticulated bones (but not an extended adult corpse) could readily have been accommodated within the oval area of stained sand (figure 5). The complete decay of such a skeleton is easily accounted for by the strongly acid (pH 5.0) reaction given by soil tests on samples collected from Feature 1.[63] This problem will be further explored anon.

Feature 2

Feature 2 lay slightly less than 5 feet south of the periphery of Feature 1, but at a greater depth, being between 65-72 inches from the present surface. This would seem to show, as would the 13-inch range of variation in the depths of the individual items of grave goods in Feature 1, that the pit floor was by no means level and even. Over Feature 2, the irregular basal outline of the 1940-41 digging could be clearly traced between depths of 35 inches at the west and 52 inches at the east end of the exposure, forming at this point the southern wall of our excavations (plate 28 and figure 5). As the work progressed to the east, south and west, it could be seen that the original pit walls had everywhere been effaced in the previous excavations. This proved to be the case throughout, except for the small northwestern segment, already noted.

At 65 inches from the surface, an oblique streak of red ocher, 20 inches long and one inch thick, showed in the lightly charcoal-flecked yellow sand of the undisturbed portion of the pit wall. Just beneath its southern end, at 70 inches from ground level, was an oval mass of the same material, measuring 17 inches across and about 3 inches deep, resting horizontally on the clean white sand of the original floor. Near the eastern edge of this mass were embedded a rectangular gorget and a narrow, side-notched point, 72 inches from the ground surface (plate 31, figures 27, 30, and figure 5). Directly adjacent, the sand for several inches was stained a brilliant orange by limonite resulting from the decay of iron pyrites from the fire-making kit, almost invariably a part of the burial equipment pro-

[62] Ritchie, 1955, pp. 21-22.

[63] Additional light on this matter may be afforded by chemical tests for available phosphates, expressed in percentage of phosphorus, in the sand of Feature 1, as compared with sand samples taken elsewhere in the pit. It has not yet been possible to obtain these analyses.

vided the deceased in the Orient and Early Point Peninsula cultural adherents to the mortuary cult.[64]

A mass of charcoal-stained sand, several inches thick, covered the lower paint deposit. This sand closely resembled the "hearth" described for Feature 1, and again there was no clear indication of burning *in situ*. In the upper portion of the ocher mass was found a thin, nearly flat stone potsherd (plate 31, figure 31), while just above it, in the dark surrounding sand, were several crumbling fragments of a very thick stone pot (plate 31, figures 21-23, 28). Two tiny calcined bone fragments occurred at the juncture of the sand and paint (plate 31, figure 26).

It was evident here, as in Feature 1, that a deposit, in this case including red ocher, was made upon the pit floor and covered over with material apparently scraped out of a fireplace situated at an indeterminate locus and containing burned bones and fragmentary and burned artifacts. A second, smaller deposit of ocher was spread upon the sloping surface of this stained sand. The whole deposit probably included human remains which were entirely dissolved by soil acids. Four sand samples taken from various points within and in the immediate vicinity of this feature gave pH readings varying from 4.5 (very strongly acid) to 5.5 (medium acid).[65]

ARTIFACTS FROM THE JAMESPORT SITE

Notwithstanding the fact that the Jamesport site had been extensively dug over, a rather large number of artifacts were found in our excavations, the most important source being the features, already described in detail, whose contents are fully illustrated on plates 29-31. The second significant source consisted of the previously undisturbed original pit fill, especially in the vicinity of the two features, but also in the intervening areas between them, as well as elsewhere in isolated patches of the deeper, unmolested pit dirt. This fill could readily be distinguished by its lighter tan color and greater compactness from the previously dug-over pit material. Most of the artifacts so derived are pictured on plates 31 and 32. The nature of their occurrence within the pit indicates that the Indians, in burying their dead, scattered offerings in the general fill of the pit, as well as placed them with the interments. These artifacts cannot be attributed to chance inclusion from an underlying or adjacent habitation component, since none apparently existed.

Our redigging of the darker, looser fill of the excavations of 1940 and later also brought to light a number of artifacts whose primary provenience is unknown. These are in large part shown on plate 31, figures 1-10; plate

[64] Ritchie, 1955, pp. 64-65.
[65] From Hellige Truog soil reaction tests done by the writer.

32, figures 1-7, and plate 33. The unillustrated material from the site is almost entirely from this third category of artifacts.

Since the total assemblage obviously pertains to a single cultural entity, the three groups referred to will for convenience be described together under several technical divisions.

Chipped Stone

Projectile points constitute 94.4 percent of the total of chipped stone implements. Of the 85 projectile points, 63 are complete, 15 broken but typologically identifiable and 7 too fragmentary for such identification. With only 9 exceptions, the points belong to the Orient Fishtail type, which thus comprises 88.4 percent of the identifiable point series of 78 specimens. The Jamesport site group as a whole consists of very well made examples of this type (described on pages 31-32), as may be seen from plates 30-33. As indicated in the plate captions, quartz is the dominant material. Of the 69 examples 50 are of quartz, 6 of quartzite, 6 of indurated shale, 5 of jasper and one each of flint and felsite.

There are 5 side-notched points, with narrow to medium broad blade (see plate 31, figure 27; plate 32, figure 4; plate 33, figures 18-20). The specimen shown on plate 32 is 4⅜ inches long and may be a spearpoint. Four are of shale, one of felsite. It may be significant that none is of quartz.

Narrow, stemmed points number 3, 2 of quartz, one of indurated shale, and are pictured on plate 31, figure 10, and plate 33, figures 12 and 16. Figure 12 approximates points of this category from the Wading River site; figure 10 (plate 31) may well be a drill (compare with plate 45, figure 22, from Sugar Loaf Hill, in which the edges are worn).

A single, fragmentary, broad, stemmed point, of quartz, resembling Midden B specimens from Stony Brook, was found at Jamesport, and is pictured on plate 31, figure 8.

The remainder of the chipped stone category consists of a single small drill point fragment of quartz; a large, rudely chipped blade section of compact shale (plate 31, figure 25); and 3 quartz strike-a-lights, 2 of which appear to have been made from fishtail points. Plate 30, figure 11, one of these, was found embedded in a mass of limonite from decomposed iron pyrites (plate 30, figure 18), as part of a fire-making set in Feature 1. This material still adheres to the specimen, which is characterized by the usual battered and blunted edges and point.

The longer example, depicted on plate 31, figure 2, came from the previously disturbed fill of the western part of the pit, at 29 inches below the surface. The fragment shown on plate 32, figure 14, was a random find in the same portion of the pit, at a depth of 46 inches. It seems to

have been made from a broken point and the battered end (uppermost in the photograph) is stained with limonite, indicating its original association with a fire-making set.

Chips and flakes of quartz occurred sporadically in the fill. There were 6 of the former, 2 of the latter. In addition, 2 thick spalls or core fragments of mottled tan and brown flint were included in the grave goods of Feature 1 (plate 30, figure 19).

Rough Stone

With a few possible exceptions, the chipped stone implements from Jamesport, in common with those from the other Orient culture sites, seem to have been produced by percussion, rather than pressure flaking. The occurrence at Stony Brook and Jamesport of what may be bone or antler punches (see plate 22, figure 3, and plate 30, figure 5) suggests that indirect percussion may have been employed in the manufacture of some of the specimens, especially those of flint (e. g., plate 31, figure 7). In the main, however, the chipping scars are rather coarse and irregular (e. g., figure 27, same plate), pointing to direct percussive techniques. Three hammerstones found on the Jamesport site would seem suitable implements to this end. They consist of quartz pebbles with multiple beveled edges, resulting, apparently, from use in chipping sharp-edged stone. This form of the hammerstone is unknown to me from any other archeological context and seems therefore of considerable diagnostic significance for the Orient culture.

A typical example, with four oblique bevels, was found in association with Feature 1 (plate 30, figure 7). It is 1-7/16 inches thick.

Plate 32, figure 22, is another such hammerstone found 57 inches deep in the undisturbed fill between the two features. The lower left bevel is almost notch-like. Both broad surfaces show scarification (X in plate). The thickness of the quartz pebble is 1⅜ inches.

The unillustrated third specimen, (Cat. No. 41282-2C) from 7 inches deep in the disturbed fill at the eastern end of the pit, is a quartz pebble 3-9/16 inches long, 1-15/16 inches wide and 1-5/16 inches thick, with two intersecting bevels or facets on either long edge and some scarification, perhaps from use as an anvilstone, on one face.

The sole remaining object in the rough stone category may well be of natural origin, fortuitously incorporated in the disturbed fill near the west end of the pit. It is a circular, diskiform, claystone concretion, ¾ of an inch thick at center, one surface of which (shown in plate 31, figure 20) bears a roughly conical pit near the center.

Ground and Polished Stone

A hunting weapon, a personal ornament (perhaps two), and an assortment of domestic utensils come under this nonfunctional heading. The first mentioned is a winged atlatl weight, commonly called a bannerstone, of a simple, imperforate form, made by chipping, grinding and polishing a piece of gray slate, 5/16 of an inch thick, which may have been found in the local drift, transported from New England. Shown as figure 20 of plate 30, it was part of the grave goods of Feature 1 (see figure 5 for location in grave). A very shallow, oblique groove, 7/16 of an inch in breadth (probably the approximate diameter of the atlatl shaft which engaged it and to which the weight was attached by thongs) crosses one face (chalked in photograph). This form is closely related typologically to the simple lunate, notched bannerstone of the Laurentian tradition in the Hudson Valley[66] and in southern New England.

While this specimen is unique in the Orient complex, one example of the short, perforated, tubular form of atlatl weight was found in the Orient No. 2 cemetery. It is of fine-grained greenish sandstone and has one convex and one concave surface.[67] It seems evident, from the presence of the bannerstone of two forms in the Orient complex, that the projectile points of this culture, specifically the dominant fishtail point, functioned as dart or javelin heads rather than arrowpoints. It is probable that the bow and arrow had not yet arrived in the New World by 1,000 B. C., the period of the Orient culture.

Several styles of the polished stone gorget are known from the Orient burial sites. Most characteristic seems to be the ellipsoidal form with narrow, bluntly pointed ends,[68] but a broad, rectangular specimen was found in the Sugar Loaf Hill site in the Long Island Chapter's excavations of 1937.[69] Our excavations at Jamesport discovered still another form, shown in plate 31, figure 30. Found embedded in red ocher in Feature 2, this ornament, well made of striped greenish gray slate, is of narrow, rectangular shape with convex long edges, and has maximum measurements of 4¾ by 1-13/16 by 5/16 inches. The perforations have been drilled and slightly countersunk from both sides. A rude arrangement of broad parallel lines has been scratched into one side, and a small area near one end of the same face is cross-hatched with narrow incisions. At least two other Orient gorgets are rudely engraved in a similar way. Of considerable

[66] Ritchie, 1958, pp. 14, 20, 58, 59.

[67] Ritchie, 1944, p. 229, Plate 107, figure 12.

[68] Illustrated in Ritchie, 1944, plate 107, figures 1-3, from photographs kindly provided by Roy Latham.

[69] Seen in the Long Island Chapter collections on display in the Suffolk County Historical Society Museum at Riverhead, Long Island.

interest is the series of 11 short, shallow nocks or incisions crossing one of the narrow, straight ends (uppermost in the photograph).

Each of these three forms of the gorget established for the Orient complex has close parallels in one or more of the Early to Middle Woodland cultures of the New York area.[70]

A possible ornamental device is reproduced as figure 24 of plate 33. It resembles a reworked stone pot lug and the broadest edge exhibits a partly smoothed-over fracture plane. The larger perforation is countersunk from both sides. The maximum thickness is ½ inch.

Stone Vessels

These are so abundant and so important in the Orient complex as to merit a separate heading in the ground and polished stone category. In prior descriptions dealing with the Point Peninsula, Middlesex and Hopewellian complexes in New York I have discussed "steatite pots" under the division of rough stone artifacts because, as a group, these vessels exhibited a technique of manufacture, or at least finishing, significantly different from those of the Orient complex, in that while the latter are smoothly finished inside and out, this treatment is very largely confined in the former group only to the inside of the pot. The exterior surface usually presents varying degrees of roughness, ranging from the bold scars of the excavating pick to narrow channel grooves, apparently produced by fine subsequent tooling. I am also under the impression that a further distinguishing difference is to be found in the larger percentage of convex-bottomed forms within the Orient series, as contrasted with flat-bottomed pots in the other complexes enumerated. Since suitable materials are not presently available for reexamination, I offer the latter statement only as a tentative observation.

The remarked difference in exterior treatment suggests to me the possibility of two centers of diffusion for the stone vessels of the Northeast, those of the Orient complex and of southern New England, which has similar vessels, centering in the latter area; those of inland New York, Pennsylvania, New Jersey and certain peripheral regions related to a primary Mid-Atlantic area center and to a secondary center in southeastern Pennsylvania. I further suspect that the original center for the whole stone pot industry of the eastern United States may have been situated in the Virginia-North Carolina Piedmont region with diffusion in all directions therefrom.

Returning specifically to the stone pots of the Orient complex (although I am sure that the following statements have a much wider applicability),

[70] See Ritchie, 1944, Plate 86, figures 21-24.

it would seem geologically incorrect to refer to the rock of which many of them are composed as "steatite" or "soapstone," a term generally and loosely employed by the professional and amateur alike in the description of stone vessels from a wide area of the eastern United States. Recognizing differentiation in mineral composition, structure, hardness and color, within the large sample secured in our combined Jamesport and Sugar Loaf Hill excavations, the writer submitted typical samples to several geologists for analysis.

According to Dr. James R. Dunn, associate professor of geology, Rensselaer Polytechnic Institute, "The minerals in the stone vessels have been identified through the use of petrographic and binocular microscopes.

"The rock type is a talc-tremolite schist and is basically the same for all specimens. The minerals are:

Talc		about 47%
Tremolite	Amphiboles	about 45%
Actinolite		about 5%
Anthophyllite		about 2%
Magnetite		about 1%

"The proportions of the minerals vary somewhat from specimen to specimen but an average of about half talc and half amphibole (tremolite) seems to be fairly close.

"A rock of this type usually forms as a result of alteration of a magnesian rock (such as a serpentine or siliceous dolomite) by thermal waters."[71]

In a subsequent reply to the writer's request as how properly to refer to this rock, Professor Dunn states: "The rock name 'steatite' is a semi-scientific term which is used more by quarrymen than geologists. It is defined in the *Glossary of Geology and Related Sciences* put out by the American Geological Institute in 1957 as 'Massive, in many cases impure talc-rich rock.' The nature of the impurities is not noted, and although the impurities do tend to be fairly uniform in talc rocks, they do differ somewhat. It is much more accurate to call the rock an amphibole—(largely tremolite-actinolite) talc rock.

"The rocks which I saw show some schistosity and the rock could, on that basis, be called an amphibole-talc schist. However using the term 'schist' might imply that the deposits are true schists. But because they very often are massive and only locally schistose I am reluctant to use the term."[72]

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[71] Letter of June 13, 1957.

[72] Letter of July 10, 1957. Dr. Dunn's assistance in this matter is gratefully acknowledged.

I shall accordingly describe the material of the Orient stone pots as amphibole-talc rock.[73]

In speculating on the source of supply of this material to the Long Island Indians, we may, in the absence of any evidence, discount the probability of the occurrence of large, random, ice-transported boulders in the glacial drift of the island, derived ultimately from a source or sources in southern New England.[74] Unfortunately, gross or macroscopic examination of the material is of little use in source identification, since so much variation exists within a single deposit. Microscopic identification of the mineral constituents, while much more useful, has decided limitations for the same reason. Spectographic analysis promises more assistance, but the method has not been extensively enough applied to the "steatites" of the east to afford as yet a body of criteria for comparative purposes.[75]

Considering the close similarity between the Orient stone vessels and those from southern New England, not only in form and size, but probably more importantly in technique of exterior surface finish, I am inclined to look northward across Long Island Sound to one or more of the numerous known aboriginal quarries of Rhode Island, Connecticut or western Massachusetts as the probable loci of manufacture of the Orient pots.[76]

Plate 29 portrays the stone pots from Feature 1 at the Jamesport site. Except for figure 1, an already fragmentary pot, these vessels have suffered the inevitable intentional breakage accorded all Orient mortuary stone or clay receptacles. In the case of figures 2 and 5, all the pieces were not recovered, suggesting that the "killing" was done outside the pit, or at least not in the immediate vicinity of the interment.

Figure 1 represents approximately half a large, probably ovate vessel of similar shape to figure 4. The old, partly smoothed-over fracture surface of the left upper edge, and the mending hole in the opposite wall (arrow), testify to prior breakage. It is thus clear that the object was a discard when deposited in the grave. The fracture line across the vessel reveals a roughly U-shaped cross-section. The maximum height is 4½ inches. Black soot-marks occur on the exterior and on the extremity of the lug. The rock is light gray in color with tan and pink mottlings. Fine striations can be seen on the surface, apparently produced with a gritty stone hone or scraper. It is interesting to note in this connection that not one example of such a tool has been reported from an Orient component, supporting

[73] The inclusive employment of the term "steatite" by archeologists has been noted by other writers. See, for example, Bullen and Howell, 1943, p. 63.

[74] Such till-enclosed boulders occur at the Wilbraham prehistoric quarry in western Massachusetts (Howes, 1944, pp. 52-53).

[75] Bullen and Howell, 1943.

[76] For descriptions of certain of these quarries see Putnam, 1878, pp. 274-276; Willoughby, 1935, pp. 157-160; Bullen, 1940, pp. 14-22; Howes, 1944, pp. 49-56; Dunn, 1945, pp. 49-52; Fowler, 1951, pp. 3-25.

the belief that the stone pots were wholly manufactured at or near the quarry sites. They may even have been obtained by the Orient people through trade relations with New England tribes.

Figure 2 is a neatly made, oval vessel with a nearly flat bottom, measuring only 1½ inches in height. The entire lip carries narrow, transverse incisions, evidently done with a sharp stone knife. There are a few soot-marks on the exterior surface, a common feature of these pots, which indicates that they are sacrificed cooking receptacles, not primarily mortuary furniture. The material is similar to figure 1.

The fragments of this pot were found in and directly above Feature 1, at depths ranging between 29 and 57 inches from the surface. Most of the fragments, however, occurred between 33 and 57 inches down.

Figure 3, 2½ inches in height, and light gray in color, seems to be a cup or small bowl. It was broken nearly in half. A small irregular piece is missing from one edge of the lip, the completely rounded edges indicating an old break. The fact that only one portion of this pot is black on the outer surface and that some smudging occurs on the interior of both pieces, suggests that the vessel after breakage was consigned to a fire, probably the mortuary fire in which various offerings, including animal food, were burned, the residue being strewn over the burial, as already described on page 55.

Figure 4 represents another entire vessel restored from two sections found in Feature 1. A small missing wall section was broken out at some former time and held in place by two mending holes on adjacent sides of the wall (arrows). The edges of the break are now smooth, showing use of the vessel subsequent to loss of the broken wall section. Three inches in maximum height and with slightly concave bottom, an unusual feature, this pot was in a very friable condition when found, being covered with cracks and fissures, evidently resulting from subjection to great heat. It was treated *in situ* with Duco cement solutions for most of a day before removal from the grave.

An extraordinarily long and narrow, trough-shaped vessel, 2½ inches high and U-shaped in cross section, is pictured in figure 5. It is of light gray stone, like figure 4, smoke-marked on the exterior and finely finished throughout.

In addition to these five pots from Feature 1, the Jamesport site yielded to our excavations a total of 89 stone pot fragments, ranging in size as shown on plates 31-33 and in thickness from 3/16 to one inch, with the majority measuring about ½ inch. It is impossible to determine the size or shape of the receptacles represented by these fragments of "killed" offerings. Some of the fragments were warped and crumbling from the effects of intense heat (plate 31, figure 28; plate 33, figure 22). One sherd

was covered with red ocher (plate 31, figure 29). It is clear that a considerable number of individual vessels are represented in our series, and a much larger number is known to have been taken from the site by the previous excavators.

Pottery

Plate 31, figure 1, and plate 33, figures 9-11, illustrate the four ceramic potsherds found in our excavations at the Jamesport site. Three of these are body sections with exterior cord malleation; figure 9 is a plain, nearly flat sherd, possibly from a pot bottom.

In the Long Island Chapter's earlier excavations here, portions of a long, oval, rather trough-shaped vessel, with nearly straight sides and a rounded lip, were recovered. This vessel, as already remarked (page 51), is an indubitable copy of a stone pot. Through the courtesy of Mr. Latham, the large compound sherd of this pot, illustrated on plate 34, figure 2, and plate 35, figure 4, was studied in detail, while an end section of the same receptacle bearing a transverse bar lug like a stone vessel, was seen on display at the Suffolk County Historical Society's museum at Riverhead.

The ceramic contents of the Jamesport site are so similar to the equally scanty pottery remains at Sugar Loaf Hill, above referred to (pages 51-52), and illustrated herein on plate 34, figures 1, 3; plate 35, figures 1-3, and on plate 46, figure 25, as to warrant their inclusion as a single ceramic ware under the following formal description:

Paste:

Temper: Crushed crystalline grit aplastic, scanty to moderate in quantity and small to large in size. Largest fragment measured 8 millimeters. One quartz pebble evident.

Texture: Coarse to medium coarse. Laminated and partly contorted. Appears to have been fillet or coil made. Color: Grayish orange (10 YR 7/4), moderate brown (5 YR 4/4), moderate reddish brown (10 R 4/6), dark yellowish orange (10 YR 6/6).[77] Color is generally similar on both inside and outside surfaces, but the sherd shown on plate 46, figure 25, is grayish orange on the outside and pale yellowish brown (10 YR 6/2) on the inside.

The interior paste is in all cases dark gray to black. Apparently the vessels were fired in an oxidizing atmosphere.

Hardness: c. 3.5

Surface finish: The entire exterior surface shows malleation with a cord-wrapped paddle, the cord-markings running in various directions, with a tendency to be vertical. One small sherd (plate 33, figure 9)

[77] On the Rock-Color Chart, distributed by the National Research Council, Washington, D. C., 1948.

has been poorly smoothed on what seems to be the exterior (the sherd is nearly flat) as well as the interior surface. Interior surface poorly smoothed, except for upper approximately one inch zone of Jamesport pot (plate 35, figure 4) which shows horizontal cord-roughening. Lip also cord-malleated in all cases.

Decoration: None.

Form:

Rim: Vertical or nearly so; thinning from 11-15 millimeters in the body to 5-8 millimeters at the lip.

Lip: Rounded.

Body: Elongate oval in two cases, like common stone pot form of same culture. Jamesport site pot has bar lug at preserved end. Second pot from Sugar Loaf Hill site round, with straight sides.

Base: Unknown. Probably rounded, as in stone pots. Flat sherd (plate 33, figure 9) may indicate use of flat-bottomed pot. Such a base on the circular vessel from Sugar Loaf Hill would result in a recepatcle similar to some Fayette Thick pots of the Adena culture.

Probable relationships:

General resemblance to Vinette 1 ware. Possible similarity to Fayette Thick just remarked. Surface treatment and certain paste traits shared with tentative type, Stony Brook Corded (see pages 37-38). The interior treatment of the Jamesport pot (plate 35, figure 4) suggests some connection with what has been termed "Modified Interior Cord-Marked" pottery (Lopez, 1957, p. 25).

SUGAR LOAF HILL SITE (SAG 1-1)

Sugar Loaf Hill, highest of the Shinnecock Hills group,[78] and still the locus of the only Orient burial component known outside the north fork of Long Island, was excavated in 1937 by members of the Long Island Chapter, New York State Archeological Association. From a height of about 130 feet above sea level, one looks southward to Shinnecock Bay and the Atlantic Ocean, and northward, across an isthmus 1¼ miles wide at this point, to Great Peconic Bay (plates 36-38). From the base of Sugar Loaf Hill to the first named body of water is only some 600 feet. The nearly level portion of the hilltop, utilized by the Indians for mortuary pits, measures approximately 110 feet on its longer or northwest-southeast axis, by 75 feet (plate 39).

[78] This group of low elevations, composed of sand and gravel, form part of the Ronkonkoma Ridge, believed to be an ice-marginal feature of the Wisconsin (Iowan-Tazewell complex?) glaciation (Fleming, 1935, pp. 223-227; Flint, 1953, pp. 901-902, 904 and plate 2).

On this rough summit plane, the Long Island chapter group found, as the principal feature, an oval pit reported by Mr. Latham as measuring some 30 by 23 by 7 feet, very similar to those at the Orient No. 2 and Jamesport sites. On the floor near the center and again near the north end were deposits of red ocher surrounded by crematory hearths filled with bits of calcined bone and with associated caches of artifacts.

This is one of the two sites which yielded pottery fragments, approximately 25 sherds representing two vessels being found near the north end. Save for two sherds, one found 48 inches deep beside a stone pot fragment, the other from a typical offering containing broken pieces of stone vessels on the pit bottom, they were scattered in the fill, intermixed with stone potsherds and other typical Orient artifacts, at or above the 2½ foot level.

Two smaller pits occurred nearby; the larger, measuring 11 by 6 by 7 feet, had at the bottom a deposit of red ocher. The north half of the floor is said to have been "shingled" with fragments of four or five large stone pots. An associated cache contained celts, pestles, paintstones, a gorget and over 30 projectile points.[79]

Between July 15 and August 3, 1956, the writer, assisted by William R. Young and Douglas F. Jordan,[80] made further explorations of the site, through the courtesy and interest of Mr. and Mrs. Grosvenor Atterbury, on whose estate it was situated, resulting in additional information and another radiocarbon date for the Orient culture. The irregular outlines of the prior excavations were found to have completely effaced within the area of our excavations, the original pit configurations, so that it was quite impossible to determine either the boundaries or exact locations of the three original pits.

Our exploratory procedure was to enclose the top of the hill within a system of interconnecting trenches, about 3 feet in width and 4 or more feet deep, as shown in figure 6. In addition, a large number of deep test pits, up to 4 feet in diameter, were sunk both within and peripheral to the trench system. The loose, dark fill of the 1937 excavations was clearly distinguishable where encountered within the trenches or test pits, as indicated on figure 6.

Feature 1

The single undisturbed feature brought to light by our search lay just outside to the southwest of the approximate northwest terminus of the 1937 diggings, and was exposed by our Trench 3 (see figure 6). It was

[79] Ritchie, 1944, p. 231. Cf. Latham, 1953, p. 110.

[80] Thanks are due Roland Waters of Water Mill, Long Island, for volunteer aid in the excavations.

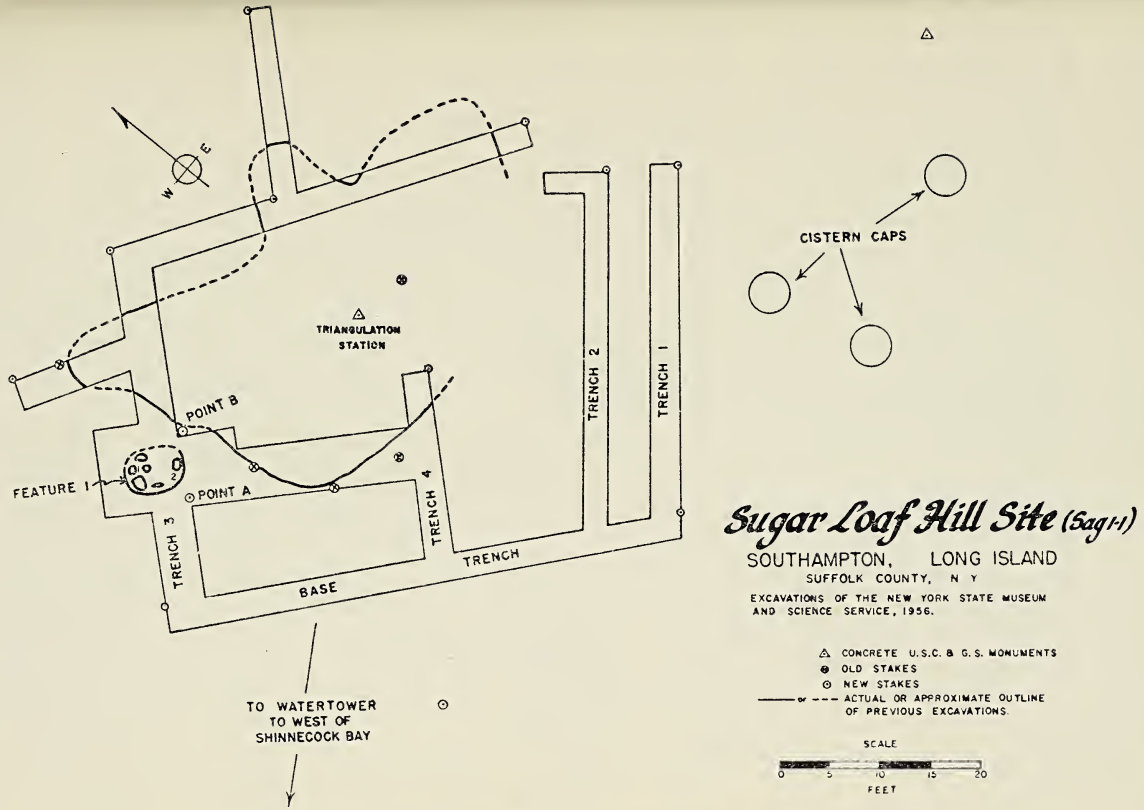

Figure 6. Plat of Sugar Loaf Hill site, showing location of Feature 1

an oval pit measuring 6 feet on the northwest-southeast axis, 4½ feet in maximum breadth and 33 inches in greatest depth, at the southeastern end. Bowl-shaped in section, it had been dug into the loose, tan-colored sand and gravel grading into white sand and gravel, the native soil material of the hill.

As most of the hilltop had been disturbed by the previous excavators, for Army or Geodetic Survey installations, or for other purposes, the unmolested soil conditions obtaining in Trench 3, particularly over Feature 1, were carefully studied. The surface soil consisted of a fine, humus-filled sand, dark gray in color, 5-7 inches in thickness, and probably representing an old duff layer (A1 soil), especially since, at its base occurred a thin (an inch or less) layer of light gray, apparently leached (A 2) soil. Beneath this the sand and gravel had a tan to orange color (B soil), becoming lighter at the bottom of the pit, where it graded into a very light tan, or nearly white, native material of the same composition (C soil).

A large, fresh exposure through a portion of the south end of the hill revealed this same soil sequence in which the tan to orange segment, here between 3 and 4 feet thick, clearly represented the weathered portion of the parent soil, an unconsolidated sand and gravel of the Colton series.[81]

In the lower portion of the pit, covering and partly enclosing the grave offerings, the sand was very dark as the result of a heavy content of charcoal, varying from minute particles to fragments nearly half an inch in length, some identifiable as carbonized twigs and bark. This dark layer ranged in thickness from a fraction of an inch on the upcurving sides of the pit to a maximum of some 4 inches near the southeastern end. The lower pit outlines were well defined by means of this layer which, being wanting in the northeastern section, made it impossible to trace accurately this portion of the feature (plate 41 and figure 6). It should be recorded that, above the confines of the dark sand, it was also impossible to distinguish the pit walls which must, of course, have extended upward to or near (allowing for a possible slight overlay of wash, actually, the likelihood of early erosion seems greater) the humus stratum which resulted from the grass and tree cover following sometime after the abandonment of the hill as an Orient cemetery. Charred organic material, carefully collected from this dark lower pit deposit covering the artifacts, yielded a radiocarbon date which will be discussed on page 75.

As at Jamesport, there was here no indication that a fire had burned in the pit, rather, the conditions closely observed supported the Jamesport data, viz., that material burned elsewhere had been poured over the contents of the grave. At the south end, two layers of this charcoal-stained sand were detected, the upper and lighter one measuring 2-3 inches thick,

[81] Cline, 1955, p. 31.

being separated by some 4 inches of tan sand and gravel fill from the thicker and darker layer below.

The grave goods were found in two groups at opposite ends of the pit. It is surmised that a bundled or flexed burial had existed between them, the osseous remains having been completely dissolved within the strongly acid medium (pH 5.5, as measured by the writer with the Hellige Truog soil reaction test method), during the approximately 3,000 years of its interment. The larger offering (numbered 1), at the northwest end, comprised a concentration of 6 projectile points, 2 hammerstones, a hematite paintstone, 4 quartz chips and a worked quartz pebble, enclosed within the dark sand and near the pit wall (see arrow 1, plate 40). A few inches distant, an adze lay on its long edge (arrow 2, same plate). Two broken projectile points (arrows 3, 4) occurred between these objects and a loose cluster of 10 stone potsherds, some of which lay obliquely against the opposite wall at the same end of the pit, as though carelessly thrown therein (see plate 40, arrow 5 and figure 6). The dark sand spread did not extend into this quarter of the pit, and the grave edge here was inferred from the position of these obliquely lying sherds.

These objects were not at the same level in the pit, thus the first stone sherds were uncovered at 16 inches from the surface, the concentration of points etc. at 20 inches, and the adze at 24 inches. This would suggest that they were placed or thrown into the grave at various times during the filling process.

Offering number 2 lay 32 inches below the surface, near the wall at the southeast end of the pit. It consisted of a compact group of 18 whole or broken projectile points of various forms and materials, one employed as a fire-striker, a siltstone chip and 2 small pieces of calcined bone, all embedded in a mass, 7 inches in diameter, of limonite, resulting beyond doubt from the decay of iron pyrite, the other member of the fire-making outfit. The siltstone artifacts exhibit extensive effects of corrosion, probably due to the action of the sulphuric acid released by the decomposition of the pyrite.[82] (See plates 41, 42 and figure 6.)

It seems probable that Feature 1 may postdate, if only by a few years, the main feature and perhaps the larger of the two secondary pit features found by the prior investigators. This supposes that the smaller pits (the one found in 1937 has not been described) peripheral to the largest one, both here and at Orient No. 2, were dug to accommodate individuals who died, subsequent to the filling of the great pit. Another, and I think less plausible explanation, would regard the lesser features as devoted to the remains of individuals of subservient rank in a social hierarchy.

[82] In this conversion process, ferrous sulphide (iron pyrite) goes to ferrous sulphate, thence to ferric sulphate, thence to limonite, with the release of sulphuric acid and water.

ARTIFACTS FROM THE SUGAR LOAF HILL SITE

On plates 43-46 are illustrated the artifacts found in our excavations of 1956 on the Sugar Loaf Hill site. Those shown on the first three plates are the burial goods from Feature 1; those on plate 46, except for figure 17, a surface find, came from disturbed fill in the large mortuary pit originally excavated by the Long Island chapter, some 20 years before, and re-excavated by us only to the extent shown within the trench lines on figure 6.

Chipped Stone

Projectile points of the Orient Fishtail type comprise 22 intact and 5 broken but identifiable examples, or 90 percent of the total series of 30 typologically determinate points from our excavations. About half of these were recovered as grave goods in Feature 1, are shown *in situ* on plates 40 and 42, and are pictured on plate 45, figures 2, 3, 6, 8-11, 16-20, 23. As noted on the caption of that plate, 6 are of quartz, 4 of siltstone, 2 of flint and one of felsite. The remaining 11 complete and 3 damaged points of this type, from the disturbed fill of the large pit, are shown on plate 46, figures 1-5, 7-10, 12-16. Thirteen of these are of quartz, one of fine quartzite.

The burial assemblage in Feature 1 also included an eared side-notched point of flint (plate 45, figure 4) and a narrow-stemmed point of fine-grained quartzite (figure 30 of the same plate). A narrow side-notched point of flint (plate 46, figure 19) came from the disturbed pit area. The first and last of these specimens have numerous parallels in Laurentian complexes of the Northeast.

The unique, isosceles triangular point, with deeply bifurcated base, shown on plate 46, figure 17, was found on the surface at the northwest edge of the site. It is of greenish-gray flint closely resembling the Deepkill flint of the Hudson Valley, is culturally unattributable and almost certainly is a stray, unrelated to the Orient complex.

A strike-a-light, fashioned from a quartz fishtail form point, is pictured on plate 45, figure 15. This artifact, with battered tip and edges, is heavily encrusted with limonite from its inclusion in a fire-making set containing iron pyrites in concentration 2 of Feature 1 (see plate 42).

Five objects from Feature 1 are thought to have been employed as drills or perforators (plate 45, figures 1, 7, 21, 22, 32), although figures 21 and 22 may be narrow-bladed projectile points. The edges of the former are sharp, as in points, of the latter, worn and rounded, as seen in many drills, including those here illustrated as figures 1, 7, 32. Figure 7 has an

adhering mass of limonite from contact with the aforementioned fire-making set. Materials are quartz and flint as specified in the plate caption.

The inclusion of chipping rejectage in the grave offerings is manifested by the objects portrayed on plate 45, figures 26, 27. The first is a medial section of a split quartz pebble, the latter, four quartz chips probably from the same pebble, as all five pieces have similar inclusions of biotite. Their location in association with the hammerstones, still to be described, is shown *in situ* on plate 40 (arrow 1). A shale chip from concentration 2 of the same feature is pictured as figure 14 of plate 45.

The only other article of chipped stone from the site seems to be a pebble hammerstone of very compact shale, nearly an inch in thickness, with one well-battered end (shown uppermost in plate 46, figure 20). It lay some 60 inches deep in the disturbed fill of the mortuary pit.

Rough Stone

Two beveled, quartz pebble hammerstones, typologically identical with those described from the Jamesport site, came from concentration 1 of Feature 1 at Sugar Loaf Hill, where they are shown as discovered, on plate 40 (arrow 1). Figure 28 of plate 45 has one strongly beveled (and weakly grooved) edge (left in illustration), and a slightly faceted opposite edge. It is 1-11/16 inches thick. The face not shown bears two scarified areas resembling anvil abrasions.

More extensively worked is figure 29, with its two broad, oblique planes, separated by a ridge on one edge, and two weaker intersecting bevels on the opposite edge. There are slight surface scarifications on both faces.

Polished Stone

In the wood-working tool depicted on plate 45, figure 33, the surface shown is somewhat more convex than the reverse side, and the still-sharp cutting edge is slightly curved, pointing toward its probable use as an adze, rather than a celt or ungrooved axe. Moreover, there is a weak lateral notch on one edge (right, in photograph). Rather rudely chipped, ground and polished, apparently in the main from long usage, it is 1¼ inches in poll thickness, made from a basaltic rock, probably dolerite, and was found on edge, as though hafted at right angles to the blade (adze-like), in Feature 1 (see plate 40, arrow 2).

An excellent example of a hematite paintstone (probably hematitic arkose from the local drift) lay among the projectile points, hammerstones etc., of Feature 1 (plate 40, arrow 1). Plate 45, figure 31, illustrates this artifact, which is ⅞ of an inch thick and has 10 rubbed facets resulting from the removal of a reddish pigment.

Stone Pots

Concentration 1 of Feature 1 included about one-half of a large stone vessel, which had been shattered into 12 fragments and scattered in the northeastern section of the grave, as may be seen on plate 40 (arrow 5). The recovered sherds are illustrated on plate 43 and restored, without loss or remainder, as shown on plate 44.

Probably oval in shape, the vessel was large, 6 inches in height, with a maximum wall thickness of ¾ inch. It is well finished inside and out, the rock being a gray amphibole-talc. Transverse incisions cross the remaining intact lip portion, a rather common decorative feature of our Orient site material. The series of lacing holes in side and bottom (indicated by arrows on plate 44), denote an old break and repair. That, after subsequent loss of the remainder, the half-pot was utilized in cooking, is evident by the extension of soot marks from the exterior over the old fracture lines, and by the partial smoothing of the rough edges thereof. The destruction for burial purposes in this case involved a decrepit, near-discard, suggesting, along with the grave goods as a whole from this feature, as contrasted with other known Orient grave lots, a relatively minor social importance for the individual interred here.

Fragments of apparently three other "killed" pots of like material were found by us in the incidental rehandling of the loose, dark back fill of the earlier excavations on the site. Shown on plate 46, figures 21, 22, 24, these comprise portions of two rims (21, 24), the latter with a nodular handle and incision-marked lip, and a body section, all about ½ inch in thickness.

Pottery

A single clay potsherd came from the disturbed fill near the northwest end of the big mortuary pit dug by the Long Island chapter. It is a thick sherd (⅝ of an inch) of coarsely grit-tempered, laminated and contorted paste, smooth inside, cord-malleated on the exterior (plate 46, figure 25). Its marked curvature suggests the possibility, already mentioned on pages 51-52, that it may pertain to the cylindrical vessel described from this site by Mr. Latham. Since this sherd was included in the formal study of the Orient pottery on pages 66-67, no further description will be required.

Chronology of the Orient Complex

THANKS TO THE COOPERATION OF TWO radiocarbon laboratories, the Orient complex is the most completely dated archeological manifestation in the Northeast. We have received Carbon-14 figures on good charcoal samples taken from three of the four cemeteries and from two loci in the

major habitation site at Stony Brook. The remarkable consistency within this series of five samples gives confidence in the reliability of the results.

For the analysis of the Jamesport site specimen we are grateful to Dr. Meyer Rubin of the United States Geological Survey at Washington; for assays of the other samples, to Prof. H. R. Crane of the University of Michigan Memorial-Phoenix Project Radiocarbon Laboratory. The subsidy for the Stony Brook analyses was derived from the second grant made to the expedition by Ward Melville of Stony Brook, as previously mentioned, while that for the Sugar Loaf Hill assay was provided by the Long Island Chapter, New York State Archeological Association. Roy Latham supplied the charcoal sample for the Orient No. 2 component, found in his excavations there of 1935 and kept in a closed and marked container until submitted to the writer in 1953. All other samples were carefully collected by the writer in the excavations described in this report.

In descending order of antiquity, the Sugar Loaf Hill site comes first, with a date of 3000 ± 300 B. P.,[83] or 1043 B. C. ± 300 years. The charcoal for this specimen came from the deposit of burned material scattered over Feature 1 (see p. 70 and plates 40, 41).

The Stony Brook site comes next with an age of 2930 ± 250 B. P., or 974 B. C. ± 250 years, for the charcoal from Feature 6, Pit 5, and 30 years less (2900 ± 250 B. P. = 944 B. C. ± 250 years) for the sample from section W5N15.[84] (See pp. 47-48.)

A precisely smilar antiquity (2900 ± 250 B. P.) was reported for the sample from the Orient No. 2 site.[85]

Youngest of the five samples was that taken from the burned material of Feature 1 at the Jamesport site (see p. 55). This charcoal yielded a radiocarbon date of 2720 ± 220 B. P. or 763 B. C. ± 220 years.[86]

Excluding the plus or minus factor of error, this series establishes a temporal range for the Orient complex on eastern Long Island of some 280 years, between approximately 1043 B. C. and 763 B. C. It is probable that the actual time span of the Orient manifestation is somewhat longer than this indicated interval, which may be extended in either direction by subsequent discoveries. It is also likely that the Orient cultural climax, characterized by the practice of an elaborate mortuary ceremonialism, coincided rather closely with the defined period.

During this span of at least 280 years, the stability of the Orient complex is attested by the uniformity of its artifact content and burial ritualism. While possibly this may be due in part to its relative isolation on Long

[83] Before the present. Sample M-586, analyzed in 1957.
[84] Samples M-588 and M-587, respectively. Date of analysis 1956.
[85] Sample M-494, run in 1956.
[86] Sample W-543, assayed in 1957.

Island, there is ample evidence, already referred to, for the assumption that the Orient people were concurrently participating in a widely diffused religious ceremonialism concerned with the welfare of the dead. In inland New York this seems to have changed but little over a very much longer period of time, as deduced from Carbon-14 datings for Point Peninsula burial sites showing similar phenomena, which range from 2448 B. C., through 998 B. C. to 563 B. C.[87] in the northern, central and western portions of the state, respectively.[88]

Some Problems and Speculations Concerning Orient Burial Customs

SINCE NO CHARCOAL IS AVAILABLE from the Orient No. 1 site, the means for placing it in the dated sequence are lacking. This site differed from the others in possessing no major pit, the burials having been made in 25 deep individual graves, reminiscent of early Point Peninsula burial practices. Like Orient No. 2, the site produced no pottery for which reason both were considered early in the site series by Mr. Latham.[89] Although not confirmed by the radiocarbon analysis of the Orient No. 2 sample, his speculation may be correct for Orient No. 1 which possibly reflects the burial procedure as it was introduced into the Orient culture. The large, communal burial features found on the other three cemeteries may constitute a unique local elaboration of the mortuary cult on eastern Long Island. A less probable alternative would regard Orient No. 1 as the most recent of the series, coming after the abandonment of the more elaborate ceremonialism.

It is also problematical whether mass burial took place in one great ceremony in these large pits, or whether individual interments were added from time to time to an open or roofed-over structure. The previous excavators did not expose the entire floor, or even large sections thereof, at any one time, in order to determine the interrelations among the numerous contained features and other data which would clarify this very important

[87] In October 1956, the Rochester Museum of Arts and Sciences and the New York State Museum and Science Service participated in the salvage excavation of a large Point Peninsula cemetery site on the Morrow farm, at the foot of Honeoye Lake, Ontario County, N. Y. The closest affinities of this site apparently lie with the Oberlander No. 2 site in Oswego County, N. Y. (Ritchie, 1944, pp. 152-160), radiocarbon dated in 1950 at 998 B. C. ± 170 years (C-192). A charcoal sample from a cremation at about 28 inches from the surface on the Morrow site was submitted to Prof. H. R. Crane at the University of Michigan by Dr. Alfred K. Guthe of the Rochester Museum. The report, received in November 1957, as this manuscript was ready for the press, gave an age to this sample (M-640) of 2520 ± 250 years, equivalent to 563 B. C. ± 250 years.

[88] Ritchie, 1955.

[89] Latham, 1953, p. 109.

point. The finding of fragments of the same vessels of stone or pottery at various places and depths in the pits,[90] apparently as part of the offerings made to the collected dead by random scattering in the fill, indicates that the filling at least was accomplished in one operation. The absence of humus stains from the floor or fill, as observed by us at Jamesport, suggests that the pit was not kept open for any lengthy period.

The character of the burials committed to the pits is also attested only by meager evidence. What seems to have been a bone bundle, much decayed, was found by Mr. Latham at Orient No. 2,[91] and he has reported cremated skeletons in the four cemeteries. Some of these remains shown by him to the writer exhibit the characteristics of burned dry bones, rather than the results of cremation in the flesh.[92] No trace of human bone was found by us in the three features excavated at Jamesport and Sugar Loaf Hill. Unless cremated, the high soil acidity and great age would doubtless suffice to encompass their complete destruction.

The probable unburned bundle and the cremation of old, dry bones suggest that corpses were kept above ground, perhaps in some kind of charnel house, awaiting the periodic observance of a mortuary ceremony at the pit. I suspect that this was a lengthy and elaborate ritualism, involving numerous magical observances, conducted by shaman specialists of the group. The evidence is unequivocal for the burning of some of the human remains and the more general practice of burning animal food and artifacts in a fire whose residue was poured over the human interment and its liberal accompaniment of grave goods. The addition of symbolic red ocher was of frequent occurrence. Most of the utensils and occasionally other artifacts testify indubitably to intentional breakage. Doubtless a great deal more could be observed or deduced from the complete and critical excavation of one of these cemeteries, if good fortune should result in another discovery and excavation under professional auspices.

It may be stated here for emphasis that, save for the use of the large burial pit and the inclusion of stone and pottery vessels as grave furniture, every trait of the mortuary ritualism observed or inferred for the Orient complex has been recorded for the burial cult of early Point Peninsula and cognate manifestations of the Early Woodland period elsewhere in the Northeast.[93]

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[90] Latham, 1953, pp. 109, 110; Ritchie, 1944, p. 231.

[91] Ritchie, 1944, p. 229.

[92] The criteria for such distinctions are discussed in Baby, 1954, p. 4.

[93] Ritchie, 1955.

Wading River Site

LOCATION

THE WADING RIVER SITE is significant in the present context for its slender contribution to knowledge of a nonfishtail, and doubtless prefishtail, Archaic complex on Long Island. Some links can be traced with the Midden B level of the Stony Brook site, even more with an apparently still earlier cultural horizon found over a considerable portion of the New York area.[94]

Its approximate location is 7/10 of a mile in an air line northwest of the village of Wading River and 2/5 of a mile due south of the mouth of Wading River, Brookhaven Township, Suffolk County.[95] The site, which was disclosed through reconnaissance by Dr. Irving Rouse, occupies an area approximately 75 feet long and 35 feet wide of the eastern part of a small valley or hollow and faces east across the broad salt marsh through which Wading River meanders before emptying into Long Island Sound (plates 47-49). This valley appears to be an erosion feature and is flanked on either side by high land rising some 40 feet to north and west and 80 feet to south, forming a part of the Harbor Hill moraine.[96]

The situation is such as to afford considerable shelter from direct north and west winds. This factor, together with the large number of deer bones and scarcity of bird and turtle remains in the midden, suggests a winter camp site, a possibility emphasized by a formerly liberal distribution over the high fields to the north and west, between the site and the Sound, of artifacts which may denote the location of summer camps.[97] A good spring still flows from the southern hill only about 100 feet from the eastern part of the excavated site.

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[94] Ritchie, n.d.

[95] Lat. 40° 57′ 35″ N., Long. 72° 51′ 50″ W., see U.S.G.S. Wading River 7.5′ quadrangle.

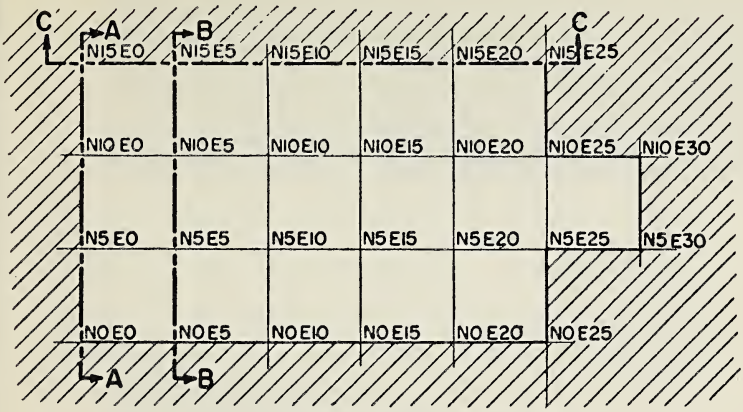
[96] Fleming, 1935, pp. 216-227.

[97] Much of this material is in the collection of George Hart of Wading River and was courteously made available to us for study. In addition to the projectile point styles found in our excavations, which comprise the bulk of the Hart collection, there are a considerable number of Orient Fishtail points, a few broad forms closely resembling the Susquehanna and Perkiomen Broad types, some slender ovate knives, drills, fully grooved stone axes, ground slate semilunar knives or ulos, stone potsherds and one or two pendant or gorget fragments.

Although there is no trace of a refuse accumulation on these fields, any such scattered thin deposit having long since been eradicated by cultivation, a small number of pits have been found, all evidently pertaining to the most recent occupation. One excavated by Mr. Hart in 1933 measured some 3 by 5 feet across, by 2 feet in depth. Mingled with the oyster and hard clam shells and deer bones were sherds pertaining to at least three pots of Sebonac culture types, triangular projectile points and a long, narrow, stemmed point, apparently a spearhead.

WADING RIVER SITE (Mrh. 1-2)

SUFFOLK COUNTY, NEW YORK

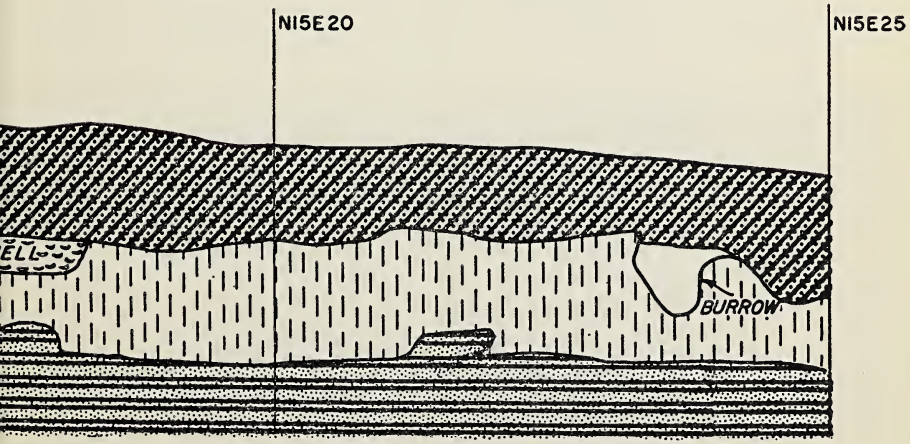


SCALE IN FEET

0 5 10 15

N

- Dark midden with shell
- Mottled black and tan sand
- Tan sand and gravel subsoil
- Sand



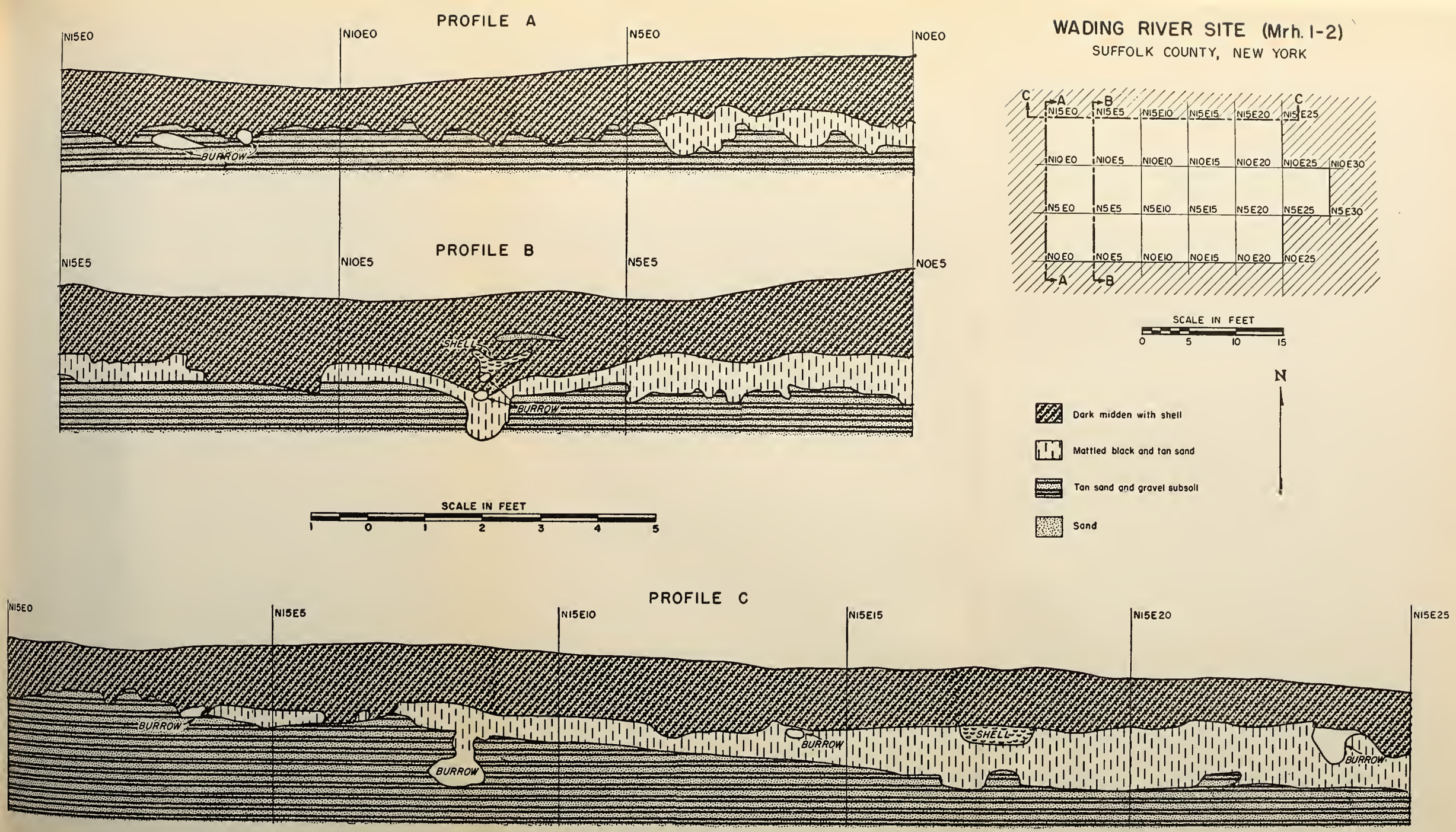


Figure 7. Grid plan and profiles at Wading River site

EXCAVATIONS

The site was visited and tested in 1955, by the kind permission of Raymond Gilleaudeau, and partly excavated between August 7-29, 1956, by the State Museum party in charge of the writer, through the courtesy of the new owner, Jacob Kahn of Mineola. The work covered a grid of 16 5-foot squares, with north-south and east-west coordinates, or 400 square feet of the site's surface (figure 7). The techniques of excavation and recording followed those described for the Stony Brook site. At Wading River, however, conditions were much less satisfactory than at the latter site, due to considerable prior disturbance by nonarcheological human activities and by the deeper burrows and dens of woodchucks.

At the time of our operations a thick sod of grass and weeds covered the area, then in peach orchard (plate 49), completely concealing the dark midden soil which was traced by a series of small test pits. Excavations disclosed a general mantle of this sandy material, with scanty to moderate amounts of crushed and whole shell and other debris, similar to Midden A at Stony Brook. This mantle varied in depth over the dug area from 10 to 20 inches and averaged about one foot thick. No plow zone could be observed. The crushed fragile shell of the soft-shelled clam predominated, but oyster was also abundant, with lesser amounts of hard-shelled clam, scallop and periwinkle. There was a marked tendency, as at Stony Brook, for shells of one kind to occur together in concentrated masses scattered throughout the midden. Such pockets contained from a few quarts to approximately a bushel of shells, and they seemed to reflect collecting activities at particular locales and the detritus of meals consumed by small groups of people.

Deer bone fragments were relatively and absolutely far more numerous than at Stony Brook, as many as 75 fragments coming from a single square, indicating a heavy reliance on hunting in the subsistence pattern of these people, and probably a greater abundance of deer at this earlier time. The sparsity of bird bones and box turtle shell fragments has already been remarked.

Fire-broken stones, resulting from cooking techniques in the absence of pottery, were profusely present, as was quartz rejectage associated with a pebble industry, for which the material lay in unlimited supply on the nearby shore of the Sound.

The dark, shelly midden layer was underlaid by an irregular, narrow zone of mottled black and tan sand which produced a low percentage of refuse (shells, bones, quartz detritus and burned stones) and artifacts (plate 50 and figure 7). It appeared to represent the upper portion of the tan sand and gravel subsoil, stained by the leaching of humates from the

superincumbent midden, and probably by the addition of organic remains of the first stages of human occupation. While I would, therefore, regard this level at the site as including a thin midden accumulation incorporated into the original duff and upper subsoil layer, I would not incline to distinguish it culturally from the overlaying dark shelly midden, since no marked typological distinctions occurred between the two, as was the case at Stony Brook (see figures 2, 3).

FEATURES

The scarce and minor features at Wading River were confined to a few shallow pits and spreads of fire-broken rock. Clearly defined hearths with discolored or indurated soil or charcoal were lacking; indeed, charcoal particles were too scarce, small and scattered to admit of gathering a sample for Carbon-14 analysis. Following is a brief résumé of the character and contents of the five pits found.

Pit 1

In section N15E5 occurred a very small pit about 9 inches in diameter traceable by the darker color of its fill from near the top of the midden just into the top of the subsoil. It contained several small dentate-stamped potsherds (plate 51, figure 7), and was obviously a very late feature, intrusive into older material.

Pit 2

Found in the same square, it was basin-shaped, 38 inches in diameter and penetrated through mottled tan sand a few inches into subsoil. It could be followed for 11 inches from its base upward into the midden which showed no trace of disturbance in its upper 12 inches. Pit 2 was therefore interpreted as an early feature of the site. The dark earth contents produced crumbly burned stones but no sign of fire *in situ,* a few clam shells, deer bone fragments and quartz rejects, including a finished blank, evidently for a narrow-bladed point.

Pit 3

A similarly shaped pit, found in section N5E0, 14 inches in diameter, its outlines could be traced from a point in the lower portion of the midden, about 15 inches below the surface, downward into the subsoil for 11 inches. Just above the level of the pit oral the midden in this quadrant of the square was traversed by an unbroken 1- to 3-inch band of crushed shells, demonstrating the early provenience of this pit feature, whose total contents comprised one deer bone fragment and one narrow, stemmed projectile point, both embedded in dark midden soil with intermixed bits of shell.

Pit 4

This was even more clearly an older feature of the site. Found in section E10N20, it, too, occupied a basin-shaped excavation, 34 inches in diameter, dug from the mottled tan and black soil zone (which material filled it) into the subsoil.

Pit 5

Found in section E10N20, this also was an older feature of the site, for it originated in the mottled tan and black soil under the shelly black mantle and extended for 15 inches into the subsoil. It was filled with the soil of the intermediate zone and produced a scatter of deer bones, clam, oyster and scallop shells, quartz chips and two narrow, stemmed points.

Stone Features

The southern half of section N15E15 and the adjacent southwest quadrant of N15E20 produced an irregular bed or layer of large pebbles and cobbles, for the most part exhibiting the scars of heat or fire. Quartzite and coarser grained crystalline rocks predominated and the fragments ranged up to about 6 inches in length. The stone mass, measuring 7 inches in maximum thickness, occurred within, but near the bottom of, the shelly dark midden. Nothing was found among the stones but a few quartz chips and unburned deer bones. A single rim sherd of shell-tempered pottery lay near the western edge, but it seemed to be intrusive here, along with glass and iron fragments of obviously recent origin.

Smaller and more nearly hearth-like was the feature, or series of three associated features, occupying a like position in the midden in section N15E5. Here occurred, on the same level (10-11 inches from surface to base), small, loose, clusters of burned stones, strung across the eastern half of the square. The largest, and central cluster, measured about 20 inches across and was in contact with two deposits of clam shells, each of about two quarts in volume. This find especially has suggested parallels already described for Stony Brook as roasting devices for shellfish and other foods. On the same level in the midden, and within 2 to 10 inches, respectively, from opposite sides of the largest cluster, were found a narrow, stemmed and a broad, side-notched point.

TYPOLOGY AND DISTRIBUTION OF THE ARTIFACTS

As at Stony Brook, the artifact category was largely restricted to projectile points, which comprised 73 percent of the total of 96 identifiable industrial objects, exclusive of quartz rejectage (84 percent if the 13 small

potsherds are excluded). The quartz pebble rejects, in all stages of manufacture from the split pebble to the discarded point blank, plus the accompanying flakes and chips which proved that the work was carried on at the site, were here relatively more numerous than at Stony Brook. Four battered quartz pebble hammerstones, lacking the beveled edges of the Orient variety, found among the scattered debris, were the probable tools employed in percussion chipping, but only one small anvil-scarred artifact was recovered (plate 51, figure 36). The near absence of such implements at Wading River and Stony Brook suggests the possible use of wooden anvils.

The 70 projectile points can be differentiated into 8 recognized style groups, all illustrated on plate 51 and analyzed for depth distribution in table 2, which also shows that quantitatively the narrow-bladed form, especially with straight stem (figures 8-11, 13-16, 19-24, 27, 28), constituted over 64 percent of all points. Moreover, this form had the broadest vertical range and the deepest occurrence on the site. Broad-bladed, stemmed, side-notched or corner-notched varieties (figures 17, 18, 25, 26) were next in frequency (13 or 18.57 percent), and while also exhibiting a wide depth (and horizontal) distribution, tended rather more to cluster in the middle zone. The isosceles triangular points (figures 2, 4, 5), in general as crudely made, apparently also by percussion techniques, as the forms already enumerated, amounted to 7, or 10 percent of the total, and nearly all occurred in the upper half of the refuse deposit as a whole. The far better (pressure ?) chipped equilateral triangles (figures 1, 3, 6) were represented by but 3 examples (4.28 percent), only one present, perhaps intrusively, below 8 inches. The two lobate stemmed points (figures 29, 30), both poor samples of this variety, were likewise found at relatively shallow depths.

These sparse distributional data tend to support the evidence from Stony Brook, and more particularly the results of excavations on deeper sites, some stratified, in eastern New York, and elsewhere in the State,[98] for the temporal priority of the narrow-bladed, Lamoka-like points and the subsequent partial temporal and spatial coincidence of these with the broad-bladed Laurentian forms. Some measure of concurrence of the triangular form, particularly the isosceles with generally excurvate edges, seems now also to be fairly well indicated for Middle and Late Archaic horizons of the New York State area.[99] Existing data would indicate that the lobate

[98] Ritchie, 1958, pp. 14, 31ff., 59ff.
[99] Ritchie, 1940, pp. 32, 48, 66-67, 88.

TABLE 2

Vertical distribution of projectile point forms on Wading River site

VERTICAL DISTRIBUTION IN INCHES	NARROW, STEMMED	NARROW, SIDE-NOTCHED	BROAD, STEMMED	BROAD, SIDE-NOTCHED	BROAD, CORNER-NOTCHED	ISOSCELES TRIANGLE	EQUILATERAL TRIANGLE	LOBATE STEMMED	TOTALS
0-2	1 1.43								1 1.43
2-4	1 1.43					2 2.86	1 1.43	1 1.43	5 7.14
4-6	6 8.57		1 1.43	1 1.43					8 11.43
6-8	7 10.0	3 4.28		1 1.43		1 1.43	1 1.43		13 18.57
8-10	9 12.86			5 7.14		1 1.43		1 1.43	16 22.86
10-12	2 2.86	2 2.86		1 1.43		2 2.86			7 10.0
12-14	2 2.86	2 2.86	2 2.86			1 1.43			7 10.0
14-16	5 7.14	1 1.43					1 1.43		7 10.0
16-18	2 2.86				2 2.86				4 5.71
18-20	2 2.86								2 2.86
Totals	37 52.86	8 11.43	3 4.28	8 11.43	2 2.86	7 10.00	3 4.28	2 2.86	70 100

stemmed points pertain to cultures of the Late Archaic-Early Woodland transitional period, while the well-chipped equilateral triangular type, often with deep basal indentation, is a good Late Woodland horizon marker. At Wading River, we repeat for emphasis, the data were too few and the soil disturbances too severe to permit more than broad comparative generalizations.

Our excavations at this site obtained three specimens of the simple, notched, winged bannerstone, which has a general distribution in Middle to Late Archaic manifestations in the Northeast. The circumstances of discovery were as follows: at a depth of 15 inches in section N5E20, a double-notched medial fragment (10 millimeters thick), of sandstone, not

illustrated, occurred in the mottled dark sand under the shelly midden layer. There were no closely associated artifacts.

A second fragment (13 millimeters thick), composed of arkose, has a shallow upper and a deep lower edge notch. The upper edge of the wing has been ground flat, probably after breakage, to obtain the red hematitic pigment yielded by this material. Another secondary use to which the fragment was put is apparent in the anvil scarification to be seen on the lower right portion in the accompanying photograph, plate 51, figure 36.

A complete bannerstone of this type, shown as figure 34 of the same plate, has only a weak upper notch. Like the other specimens described, it was produced by the chipping and grinding, especially on the edges, of a natural flat pebble (maximum thickness 10 millimeters), in this case arkosic sandstone, doubtless from the local drift, but ultimately derived from the Triassic formations of the Connecticut Valley. It was found in a preliminary small test pit, which fell subsequently within the confines of section N10E0, 12 inches below the surface, in shelly midden debris, 3 inches from its base.

A polished rectangular celt, a notched chopper, and two paint stones, illustrated on plate 51, figures 31, 33, 32, 35, respectively, constitute the remaining stone artifacts from the site. The celt is well made, by pecking, grinding and polishing, from a quartzite cobble, and is 17 millimeters thick. It lay in a nearly vertical position, 17 inches below the surface, in the stained sand under the shell deposit in section N5E20.

The chopper, broadly flaked from a split quartzite cobble, preserving the natural surface on one face, is 17 millimeters in maximum thickness, and has a slightly battered edge. It came from the lower part of the shelly midden, 11 inches deep, in section N5E15.

The paintstones, of Triassic arkose (see page 18), have the following provenience: figure 32, section N10E20, 17 inches deep in stained sand under shelly midden; figure 35, 10 inches down in shelly midden of section N10E5. Both have superficial scratches and grooves, presumably to obtain the red pigment; otherwise they are natural drift pebbles.

The profusion of fire-shattered rocks, the stone features alluded to, and the absence of cooking utensil fragments from the greater portion of the midden, attest to the preceramic status of all but the latest occupants at Wading River. Actually, the site as a whole may be considered virtually nonceramic since the 13 trivial potsherds recovered evidently pertain to no more than three or four pots. In addition, there is a single small sherd of a stone vessel, found 6 inches deep in the upper half of the shelly midden in section N15E0.

Plate 51, figure 7, illustrates a rim and two neck sherds of a dentate stamp-ornamented pot, 10 fragments of which account for most of the

pottery found. All these sherds came from depths between 5 and 7 inches in the upper part of the shelly midden in adjoining sections N15E0 and N15E5. The ware is thin (4-6 millimeters), sparingly tempered with fine grit, has a hardness of 3 and is moderate to dark yellowish brown in color (10 YR 5/4-10 YR 4/2). The body, of indeterminate shape, was smooth outside and in, the neck and slightly everted rim decorated as shown, and the lip nearly flat, outsloping and similarly embellished.

This is a late-looking, sophisticated ware, probably left by the same group who lost the equilateral triangular points.

A few nondescript, shell-tempered pottery scraps, with corded or brushed exteriors, found between 6 and 10 inches from the surface in sections N10E0 and N15E15, complete the ceramic inventory.

The bone industry on the site was even more feeble. Two splinter awl tips from 7 and 11 inches down in the shelly midden of sections N5E5 and N15E10, respectively, are all we have to report. Considering the abundance of refuse bone throughout, and the high pH of the various soil levels,[100] the reasons for this paucity are surely cultural, but at present they remain unknown.

CONCLUSIONS

Specific interpretations and conclusions regarding the Wading River site are difficult to deduce for reasons already stated. It would seem that the excavated site may have served intermittently, over quite some period of time, as the winter camping spot for most of the groups who, in summer, established temporary quarters on the airy highland to the north and west. By far the greater part of these groups consisted of hunters and shellfish gatherers, whose culture conformed to the local facies of the Middle Archaic Laurentian tradition. During some part of this period, in all probability, a cognate group was accumulating Midden B at Stony Brook. At the western end of Long Island, the Garvie Point site seems to fit into this cultural picture,[101] as do certain sites in the Hudson Valley, e. g., Bannerman and South Cruger Island.[102] A radiocarbon date for the Bannerman site of approximately 2524 B. C. indicates the probable order of antiquity of the Middle Archaic period in eastern and coastal New York.[103]

I suspect there was a still older cultural phase at Wading River which antedated anything found at Stony Brook. The narrow-bladed, Lamoka-like

[100] Tests made by the writer with the Hellige Truog Soil Reaction Tester No. 693 on samples from various levels yielded results as follows: shelly midden soil, 8.0; mottled black and tan sand, 8.0; subsoil, 7.9.

[101] Patterson, 1955, pp. 1-3.

[102] Ritchie, 1958, pp. 62-90.

[103] Ibid., p. 67.

points predominating in the collections from both high and low ground components at Wading River, may here, as elsewhere in the New York area, attest to an Early Archaic horizon preceding the Laurentian.[104] I have seen some Long Island collections based on surface sites which suggest the existence of small components yielding such points exclusively or nearly so.

A probable comparable site was destroyed by wave erosion on the north-central shore of Fishers Island, Suffolk County, N. Y., lying about 12 miles northeast of Orient Point, Long Island, off the coast of Connecticut. Plate 52 depicts a representative series from this site, known as "Arrowhead Beach," from the collection made there by Henry L. and H. Lee Ferguson, Jr. of Fishers Island, through whose courtesy the site was visited by the writer in November 1955. The presence of a few narrow triangular point forms and of the grooved axe is especially noteworthy, since both traits are unknown from Early Archaic complexes in inland New York.

The grooved axe, however, is an item of this period in the Southeast (as is the bannerstone) and the writer has postulated the diffusion of both these traits northward into various cultures sharing the Laurentian tradition during Middle Archaic times.[105]

To return to Wading River, the Orient Fishtail type points in the Hart collection, found on the higher ground, were not represented in our excavated series from the valley site. Probably this segment of the local history did not involve the latter locale. This occupational episode would doubtless equate approximately with the Midden A phase at Stony Brook, radiocarbon dated around 1000 B. C., and falling within the interval of transition from Late Archaic into Early Woodland times in this area.

Still later, by an unknown temporal increment, pottery-making groups of Sebonac cultural affinity, on the hill, and of indeterminate affiliation in the valley, brought to a close with their very brief sojourning, the Indian history of the Wading River site.

General Conclusions

THE SITES DISCUSSED IN THIS REPORT on the excavations, during 1953, 1955 and 1956, of the New York State Museum and Science Service on eastern Long Island, in some measure clarify the Archaic and those segments of the island's prehistory which are transitional-into-Woodland. Apparently the Laurentian tradition of Middle Archaic times, widely distributed throughout the Northeast, is represented by the lower level artifacts from the Stony Brook site and by a portion of the Wading River

[104] Ritchie, n.d.

[105] Ritchie, 1951a, p. 131.

material. At the latter site there is also evidence for the extension to eastern Long Island of an Early Archaic tradition noted in the Hudson Valley region, and probably present as well in southern New England. To this still unnamed tradition belongs the well-defined Lamoka complex of central and western New York. The Lamoka complex as there defined is *not,* however, recognized in eastern New York or New England. It is simply the narrow-bladed, stemmed or side-notched Lamoka-like points of the eastern area which suggest the presence there of an Early Archaic tradition to which the Lamoka complex also pertains.[106] While some stratigraphic evidence exists in central New York for priority of the Lamoka complex and in eastern New York for an underlying narrow point horizon,[107] in the latter region and in adjacent New England the materials of the two traditions seem more often to be intermixed in the same components. This would suggest the cultural blending of traits of both, previous to the arrival on these sites of the archeologically observable complex.[108] The solution of this perplexing problem requires the discovery and careful excavation of more stratified and single component sites in the eastern area.

The Orient complex, as seen with the addition of the new data described in this report, constitutes a link between the Late Archaic and Early Woodland stages of cultural development on Long Island. The chronology of this transitional phase, drawn from a series of five highly consistent radiocarbon dates, representing the Sugar Loaf Hill, Stony Brook, Orient No. 2 and Jamesport sites, seems firmly established in the period of approximately 280 years intervening between about 1043 B. C. and 763 B. C. This period falls within the radiocarbon dated span of approximately 1,885 years, between 2448 B. C. and 563 B. C., during which mortuary ceremonialism of comparable character was being observed in inland New York, and probably southern Ontario and elsewhere in the Northeast.[109] (See pp. 49-52, 74-77.)

These cultural and temporal factors tend to buttress the writer's hypothesis of a general eastward diffusion through New York and probably other portions of the Northeast, of an Early Woodland complex containing, among other innovations, the first pottery and stone gorgets in the area, and a burial ritualism characterized by cremation, use of red ocher, abundant grave offerings, intentional breakage of grave goods, and other traits.[110] It would seem that the differential diffusion of a group of ideas,

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[106] Ritchie, 1958, pp. 60-61, 98.
[107] Ibid. pp. 12, 14, 31-33, 45, 59-61, 68.
[108] Ibid., pp. 31-32, 70-71, 100.
[109] Ritchie, 1955.
[110] Ibid., pp. 69-76.

both secular and religious, and their tangible expression in material cultural elements, had inaugurated the series of changes in various parts of the Northeast which constitute the transition from the Late Archaic into the Early Woodland cultural stage. Progressive modifications of this kind, due in part to continued selective diffusion, ultimately culminated in the establishment within the area of the regional variants of the Woodland pattern.

Our Long Island data fail, however, to provide completely satisfactory answers to critical problems of cultural continuity with change due to diffusion. There are vague suggestions of possible trait persistence from lower to upper levels at Stony Brook, and the Orient complex is shown to contain such characteristic traits of the Laurentian tradition as the gouge notched adze, bannerstone, side-notched and eared point forms.[111] The distinctive Orient Fishtail type of projectile point has a wide distribution, chiefly on surface sites, over eastern and southeastern New York, and a more limited occurrence in the central region of the State. At the carefully excavated Lotus Point site in the mid-Hudson Valley it has a stratigraphic position (with weak stone pot associations) between apparently Middle Archaic and Middle Woodland components.[112] Its limited distribution as a minor element on certain Connecticut,[113] Rhode Island,[114] and New Jersey[115] sites, provides no clear insight into its cultural and temporal significance in these areas.

Stylistic similarities in shoulder and stem are discernible between the Orient Fishtail and Susquehanna Broad points, while possible intermediate forms are recognizable in eastern, southern and central New York (see plate 53). Although the complex (or complexes) to which the Susquehanna Broad point in Pennsylvania and New York belongs is very imperfectly known, it certainly contains the stone pot, and probably the gorget, and its intermediate status between Late Archaic and Early Woodland seems unequivocal.[116]

Perhaps the Orient Fishtail type of point was developed locally in eastern or southeastern New York from a regional, somewhat narrower-bladed and sloping shouldered variant of the Susquehanna Broad point. A surface-collected series of such points from the Van Orden site in the Hudson Valley, Greene County, N. Y.,[117] exhibits intergrades in both directions

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[111] Ritchie, 1944, pp. 227-235.
[112] Ritchie, 1958, pp. 25-34, 100.
[113] Praus, 1942, pp. 38, 58.
[114] Fowler and Welt, 1955, pp. 6-9.
[115] Cross, 1941, pp. 31-34, 90-93.
[116] Ritchie, 1945, pp. 13-16; Witthoft, 1953, pp. 7-13.
[117] Ritchie, 1958, p. 30.

(plate 53, figures 5-8). The period would have been Late Archaic times, when the use of the stone pot seems to have been spreading through the Middle Atlantic and lower portions of the northeastern areas. These traits may have been adopted by Long Island groups whose cultures were rooted in the ancient and long enduring Laurentian tradition of this region. The resulting manifestation may have been a pre-Orient complex as yet unrecognized, but suggested by the presence of Orient Fishtail points and stone vessel sherds on Archaic surface sites of wide distribution over the island.

The later addition, still prior to c. 1000 B. C., of some of the traits characteristic of the Early Woodland pattern, specifically pottery of Vinette 1 ware, stone gorgets and the burial cult, may have resulted in the further modification of this hypothetical pre-Orient stage into the recognized Orient complex. The role of stimulus diffusion in the dissemination of the pottery seems well attested by the initial use of this new medium in copying the existing stone vessel forms. While some of the Orient gorgets are similar in form and material (striped slate believed to be native to the upper Great Lakes area) to those of Early Woodland manifestations of inland New York, and the elements of the burial cult are remarkably alike in most respects, the disparity in the majority of specific artifact traits leads to the assumption of the spread of a religious concept concerned with the welfare of the dead, rather than an actual movement of people and their goods onto Long Island.

The full force of this ideology seems to have been exerted on an eastern Long Island group or groups of the Orient culture, else how explain the extreme eastern location of the cemeteries? No burial ground was found in connection with the Stony Brook site, nor have any graves attributable to the Orient culture ever been uncovered elsewhere to my knowledge. It appears possible, however, that certain hills of eastern Long Island were selected for burial purposes by Orient culture groups of the cult-inspired period whose living communities lay considerably removed therefrom. This hypothesis receives support from the lack of known settlement sites in the vicinity of the cemeteries and, conversely, the apparent absence of burials at Stony Brook and Muskeeta Cove. The notion of a sacred precinct for the dead seems to have been a part of this mortuary cult, persisting even into its final development, as postulated by the writer, in Middle Woodland Hopewellian manifestations. Moreover, as respects the early, northeastern expression of the cult, an orientation toward the east, possibly toward the rising sun, seems clearly evident.[118] Hence the utilization on eastern Long Island of natural mound-like knolls, another well established cult trait, fits well into this pattern, as does the emphasis on fire shown in the practice of cremation and the burning of offerings of food and artifacts, as well as

[118] Ritchie, 1955, p. 61.

the placing of fire-making sets, the means of creation of fire, in virtually every grave. These diagnostic traits, coupled with the use of red ocher, abundance of grave goods, some intentionally broken, and, indeed, nearly every known feature of the earlier dated burial cult in northern and central New York, serve to connect beyond cavil the Orient mortuary manifestation with the early Point Peninsula, as participants in a similar religious ritualism which, on current radiocarbon reckoning, flourished in New York State between c. 2448 B. C. and 763 B. C.[119]

The relationship of the Orient culture at its climax to subsequent culural complexes in the area is as obscure as the antecedent connections with the Late Archaic, already discussed. The cult participation stage of Orient, some 280 years in duration on the data in hand, was probably succeeded, as in the late Point Peninsula culture stage of the inland New York State area, by a more secular orientation, and I would incline to connect this later stage with the North Beach Focus of Smith.[120] While it seems clear to the writer, and currently, I believe, to Smith,[121] that the Orient complex cannot simply be regarded as the mortuary expression of the North Beach Focus, as was formerly postulated,[122] the small percentage of Orient Fish-tail points reported by him for North Beach and our recovery of a few sherds of North Beach-like pottery (North Beach Brushed? and Matinecock Point Stamped?) in the upper level of the Stony Brook site, suggest a continuation of Orient cultural development, with modifications introduced into western Long Island from the mainland, through the interchange of ideas, filtering into the southeastern New York region.

On the whole, I am inclined to think that the process of interchange of ideas, probably freely in all directions, and governed by the reasonably well understood mechanics of diffusion, would suffice to explain, if our data were more complete, a considerable part of the complex picture of cultural change within the peripheral Long Island area, from the Archaic period to the major "time of troubles" of the local inhabitants, beginning early in the 17th century.

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[119] Ritchie, 1955, pp. 61-76.
[120] Smith, 1950, p. 135.
[121] By conversation of August 1956.
[122] Smith, 1950, p. 136.

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* * *

PLATE 1

Southwestern portion of Stony Brook site, looking southwest to salt marsh bordering Aunt Amy's Creek, before start of excavations

PLATE 2
Upper portion of Pit 4 (Feature 5) exposed during beginning of excavation of section W10N5, Stony Brook site, looking northeast

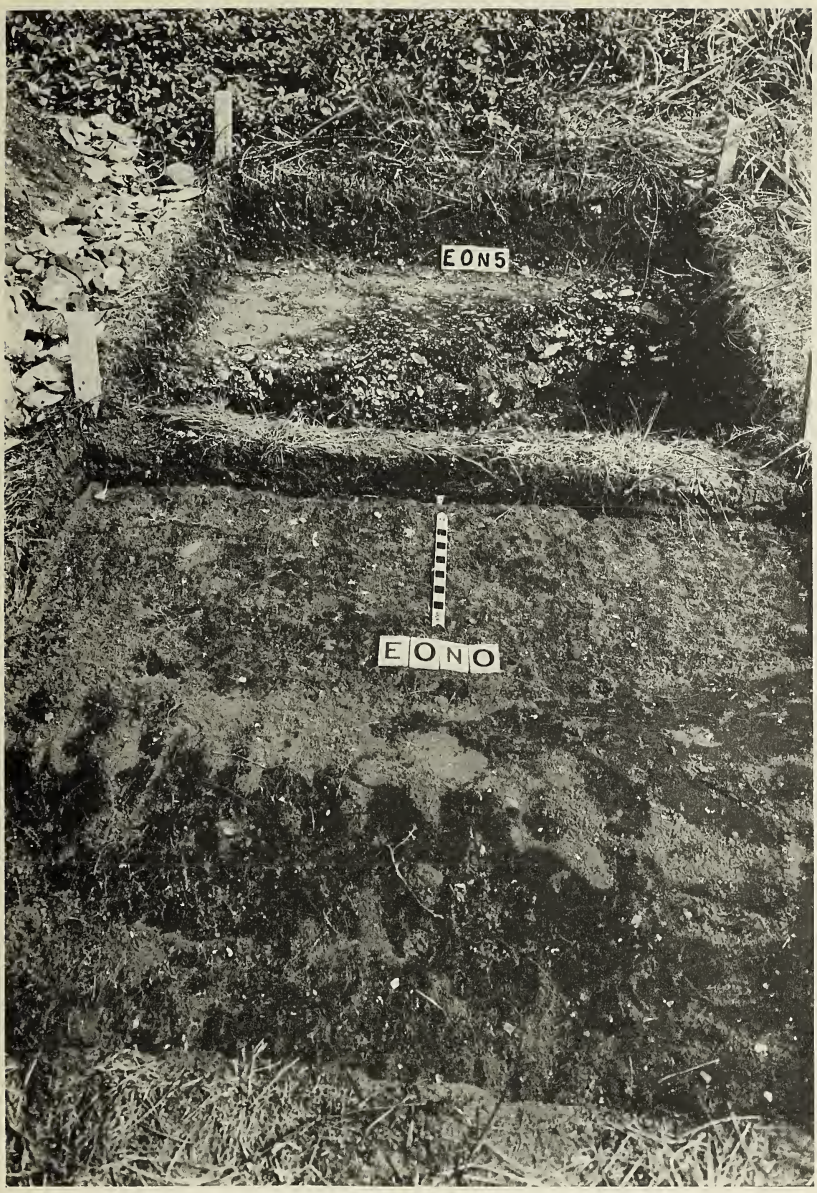

PLATE 3

Section E0N0, Stony Brook site, stripped, and E0N5 under excavation, showing upper fill of Pit 1 (Feature 2), looking north

PLATE 4
Section E0N0, Stony Brook site, excavated to expose south end of Pit 1 (Feature 2), looking north

PLATE 5

Section through Pit 1 (Feature 2) Stony Brook site, showing A, B and C complexes, looking north

PLATE 6
Section through northern portion of Pit 1 (Feature 2), Stony Brook site, looking north

PLATE 7

Portion of top of Pit 4 (Feature 5) Stony Brook site, in northwest quadrant of section W10N5. Base of Midden A marked by knife.

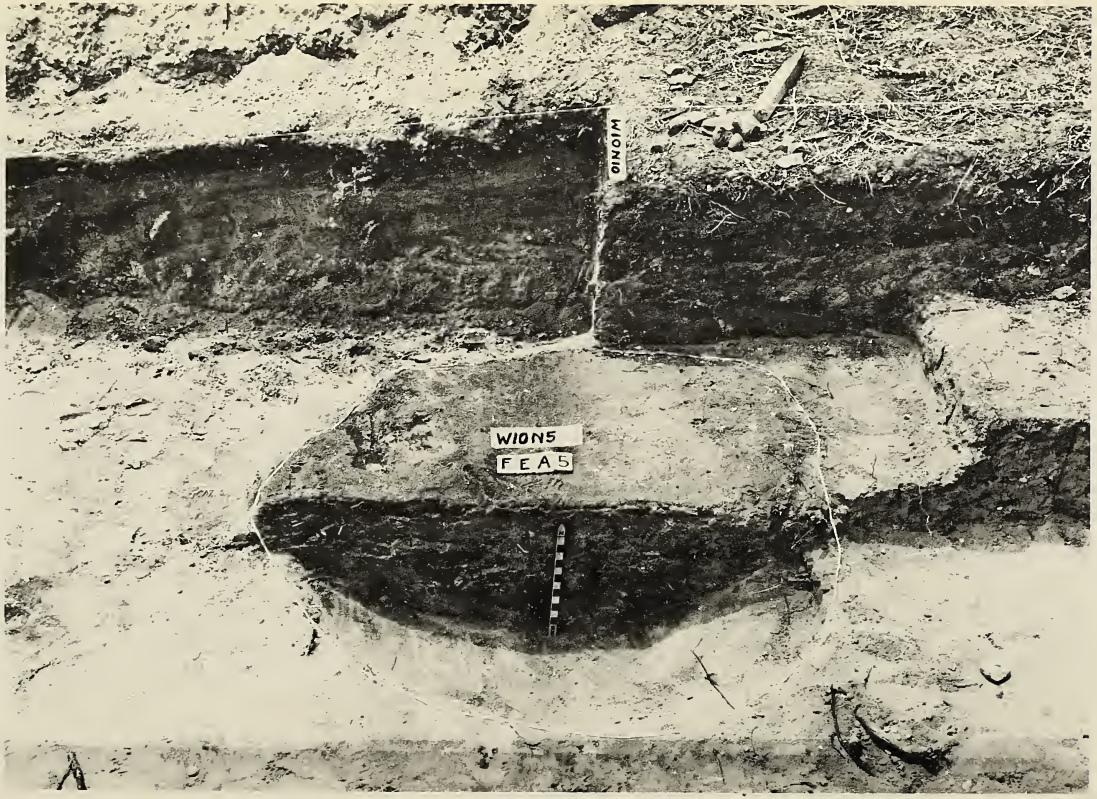

PLATE 8
Lower fill of Pit 4 (Feature 5), Stony Brook site, looking west

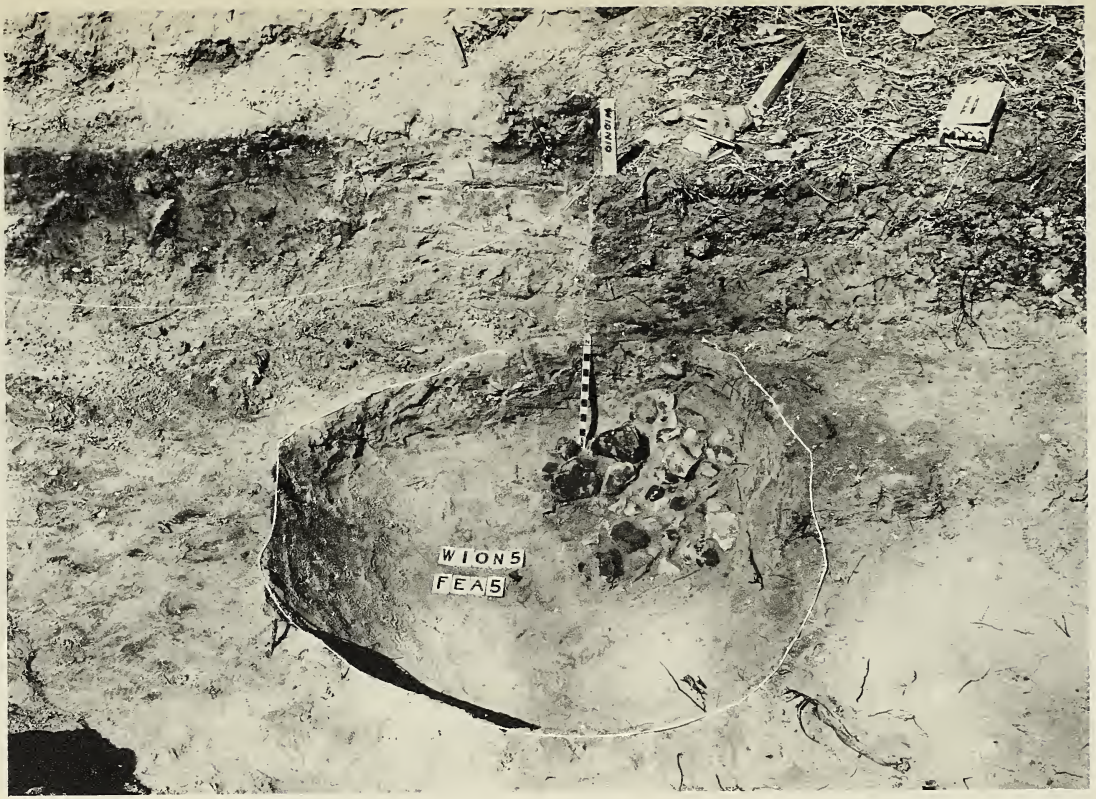

PLATE 9
Burned stones at base of Pit 4 (Feature 5), Stony Brook site, looking west

PLATE 10
Section through Pit 5 (Feature 6), Stony Brook site, showing various fills, looking northwest

PLATE 11

Section through Pit 5 (Feature 6), Stony Brook site, showing bed of burned stones at base, looking northeast

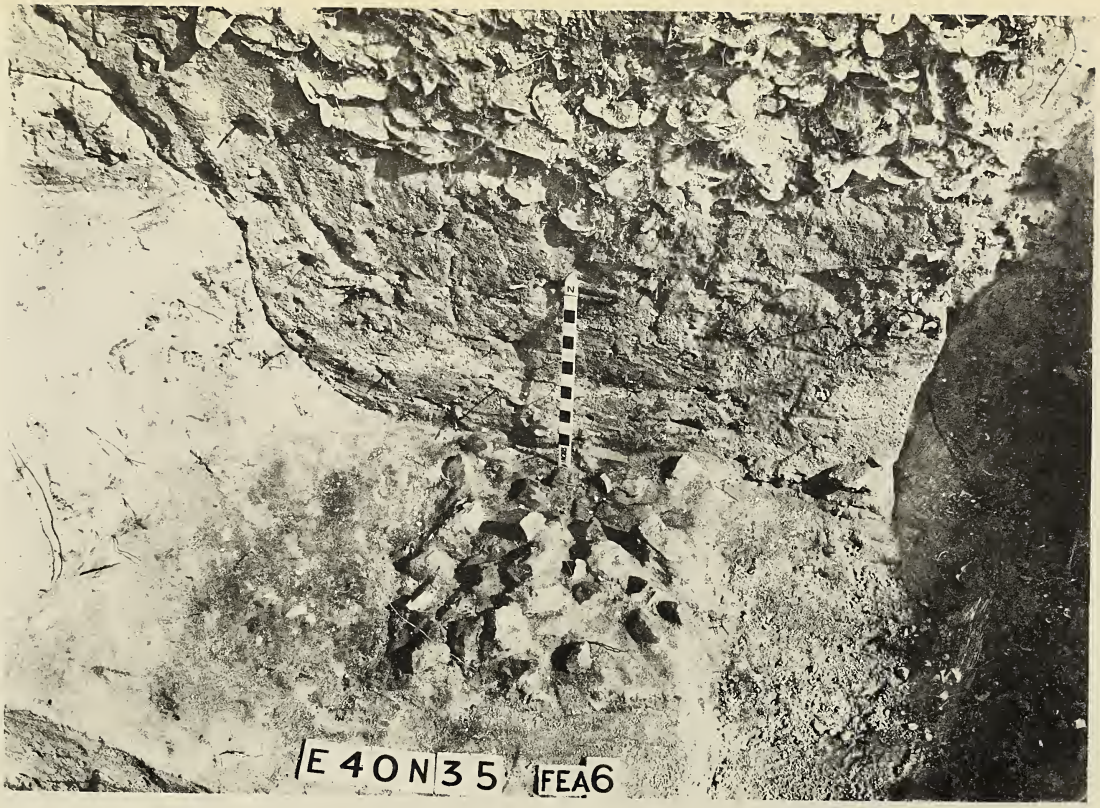

PLATE 12
Section through basal fill of Pit 5 (Feature 6), Stony Brook site, showing portion of burned stone bed, looking northeast

PLATE 13
Burned stone bed fully exposed at bottom of Pit 5 (Feature 6), Stony Brook site, looking northeast

PLATE 14
Southwestern portion of Hearth 2 (Feature 7), Stony Brook site, looking northeast

PLATE 15
Profile through center of Hearth 2 (Feature 7), Stony Brook site, looking north

PLATE 16

Exposed northern half of Hearth 2 (Feature 7), Stony Brook site, and adjacent Burial 1 (Feature 8), looking north. Note outline of Midden B beneath features.

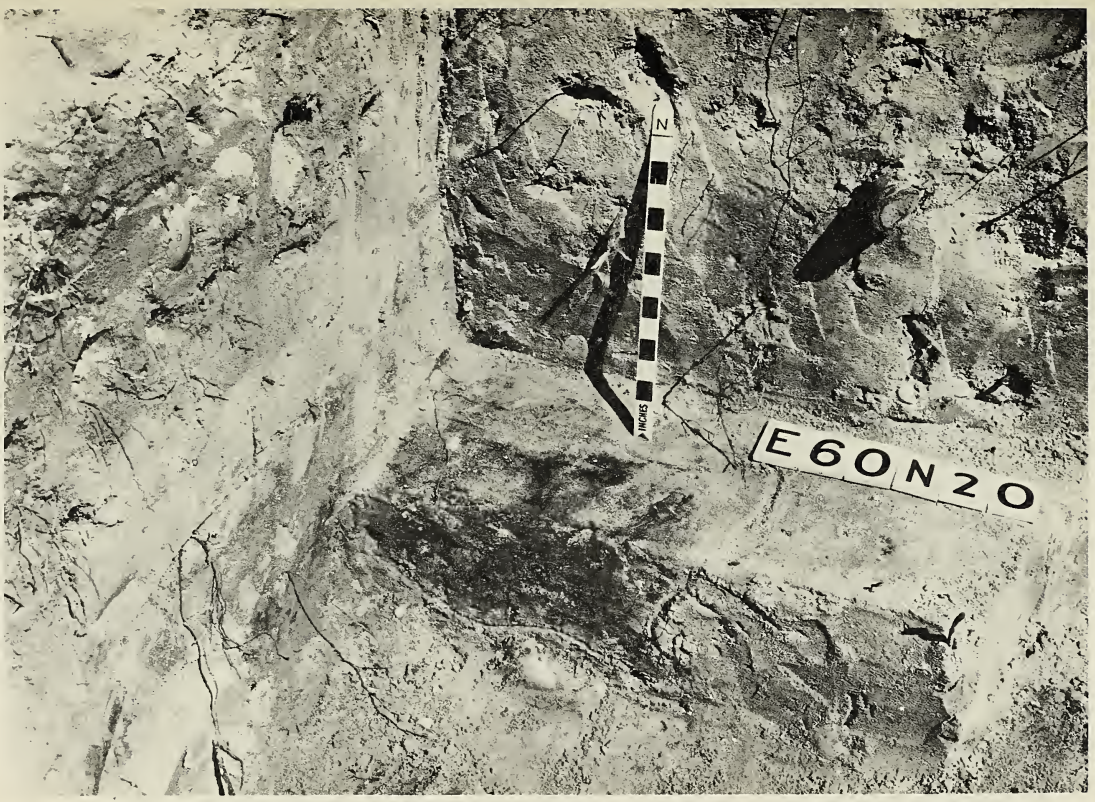

PLATE 17

Small hearth, number 4 (Feature 10), in northwestern quadrant of section E60N20, Stony Brook site, in Midden B horizon, looking north

PLATE 18
Flexed infant burial (No. 1, Feature 8), Stony Brook site, looking south

PLATE 19
Scattered dog bones (skull to right) (Feature 12), in Midden A, Stony Brook site, looking northwest

PLATE 20

Orient Fishtail type projectile points from the Stony Brook site. Materials: 1-6, 16, 30, 31, quartzite; 11, gray flint; all others quartz.

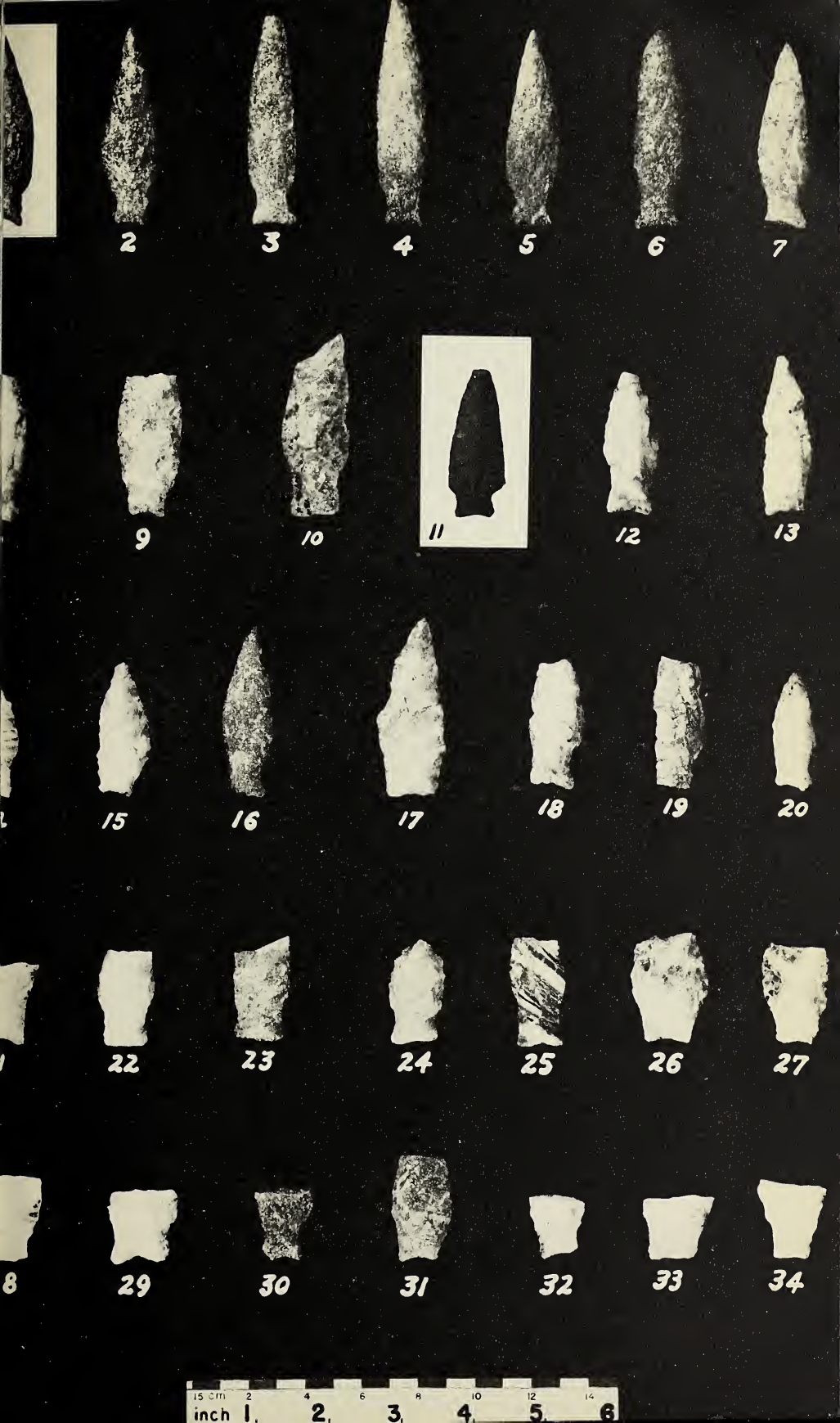
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PLATE 21

Stemmed and side-notched projectile points from the Stony Brook site. 1-3, 11, small, stemmed; 4, 5, narrow, stemmed; 6, 13, 14, 15-17, 22-28, broad, side-notched; 7-10, 12, 20, 21, small, side-notched; 18, 19, narrow, side-notched; 29-37, broad, stemmed.

Materials: 4, 6, 31, gray flint; all others quartz.

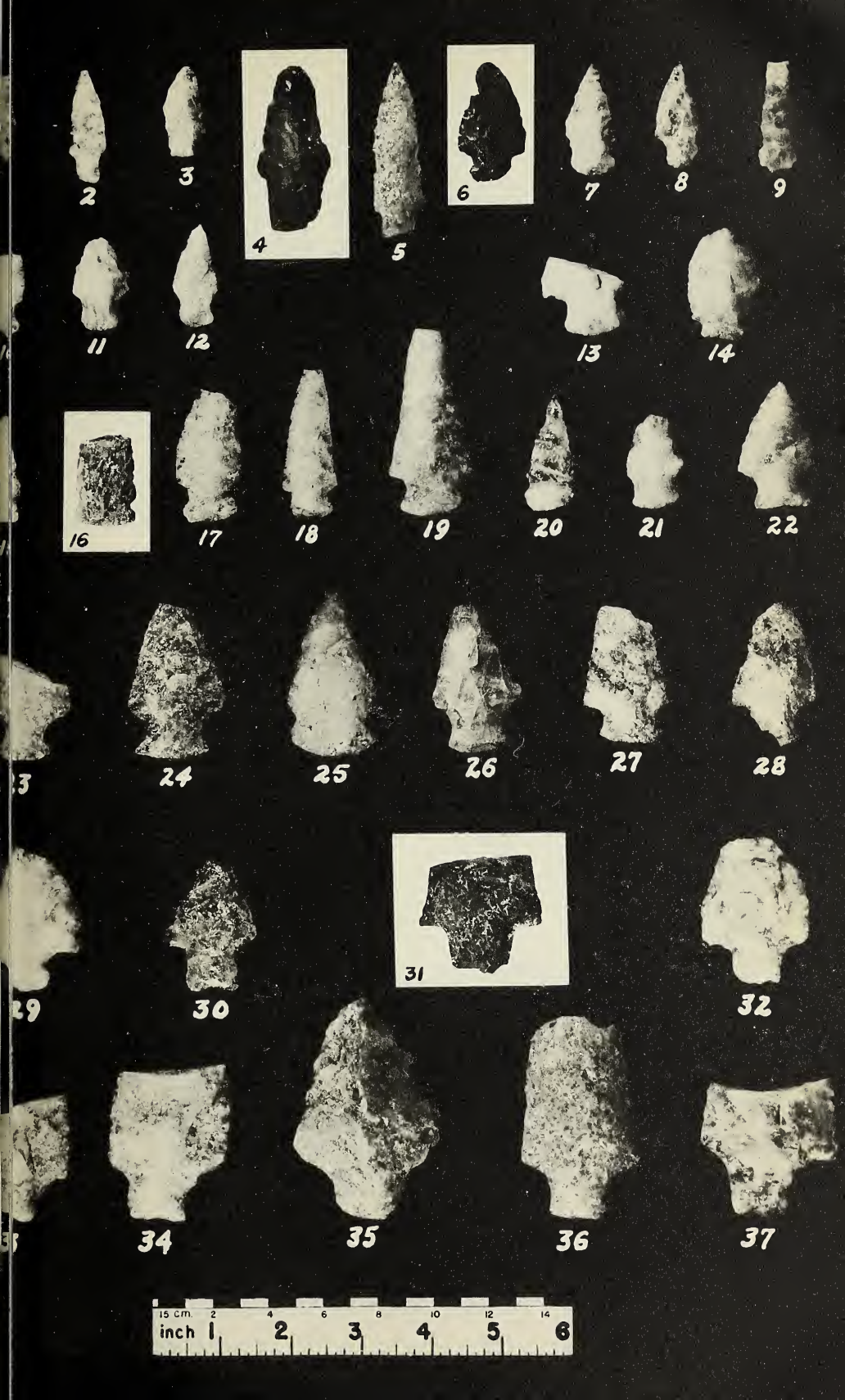
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PLATE 22

Bone, shell, chipped and rubbed stone artifacts from the Stony Brook site. 1, 7, 8, 9, rough splinter awls; 2, polished splinter awl; 3, cylindrical flaking tool (?); 10, discoidal shell bead; 4, 5, lobate-stemmed points; 6, 11, isosceles triangular points; 12, 13, equilateral triangular points; 14-16, point sections of chipped stone drills; 17, basal portion of chipped stone drill; 18, prismatic flake end scraper (?); 19, 20, lozenge-shaped points; 21-26, ovate and trianguloid knives; 27, graphite paintstone; 28, natural arkose pebble; 29, 30, paintstones of arkose (arkosic sandstone with hematite cement).

Materials: 6, quartzite; 13, 14-16, 18, gray or black flint; others, except as noted above, of quartz.

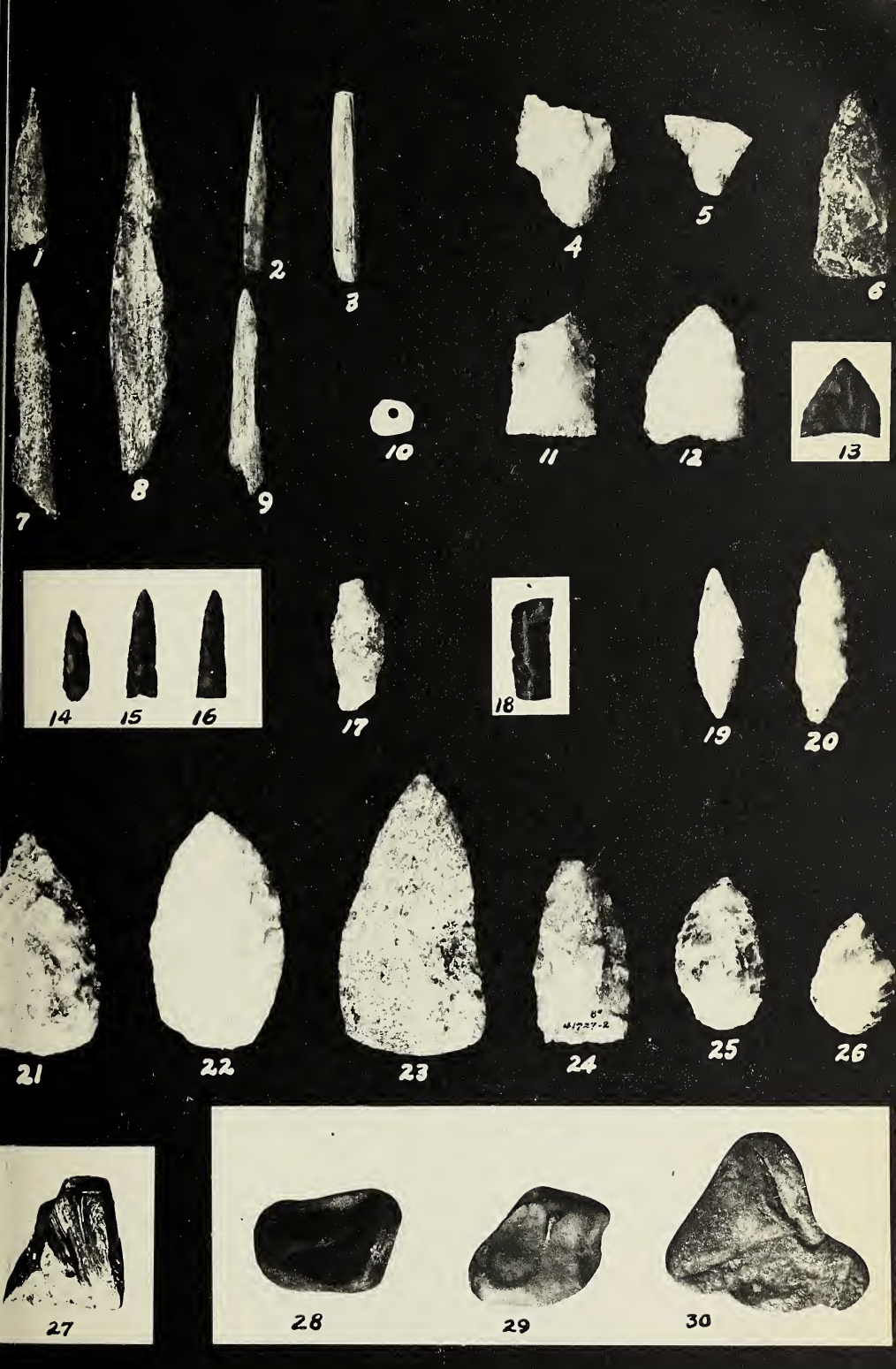
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PLATE 23

Stone artifacts from the Stony Brook site. 1, natural quartz pebble; 2-7, stages in the reduction of such a pebble by percussion chipping into a fishtail point; 8-13, flakes and chips of various sizes, thrown off in progressive reduction operations (based upon size of flake scars of rejects, 2-7); 14, 15, 19, pebble hammerstones; 16, rude, side-notched celt (?); 17, lugged fragment of stone pot; 18, broken anvilstone.

Materials; 16, 19, sandstone; 17, kyanite schist (?); all others quartz.

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PLATE 24

Potsherds from the Stony Brook site. 1-4, Sebonac Stamped (?), 2 is a rim sherd; 5-7, Matinecock Point Stamped (?); 8, Vinette 1 (?); 9, 10, 14, Stony Brook Corded, 10, 14 from same vessel, 14 shows interior surface; 11-13, North Beach Brushed (?), 11, 12, rim sherds, 13 shows interior surface.

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PLATE 25
Jamesport site, looking southeast. Arrow points to beginning of 1953 excavations.

PLATE 26

Feature 1, Jamesport site, showing most of the artifacts exposed *in situ*. Few still uncovered in back wall at X. Arrow (right) points to group of projectile points. Note outline of original pit on left and soil demarcation between lighter undisturbed lower fill and darker upper fill turned by previous excavators.

PLATE 27
Closer view of artifacts shown in plate 26. Arrow indicates points.

PLATE 28

Feature 2, Jamesport site. Gorget held at locus of discovery against background of red paint. Arrow shows troweled line of differentiation between disturbed upper fill and intact original lower fill of mortuary pit.

PLATE 29

Stone bowl fragments found in Feature 1, Jamesport site. Figures 2-5 have been partly or completely restored.

Material: amphibole-talc.

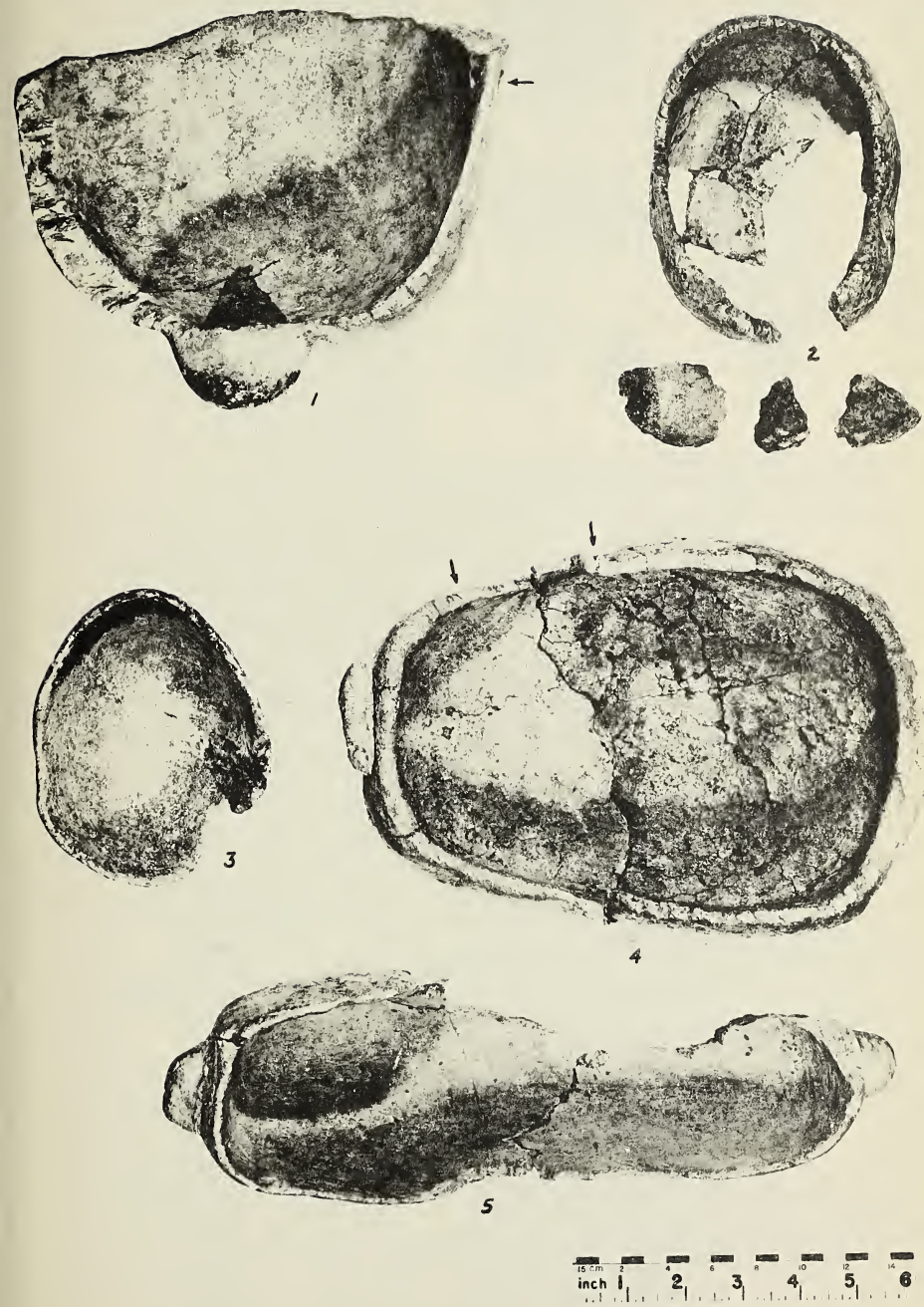
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PLATE 30

Calcined animal bones and stone artifacts found in, or associated with Feature 1, Jamesport site. 1, bird bone fragments; 2, section of mammal radius (?); 3, fragments of deer phalanges; 4, 5, antler tine fragments, 5 may be portion of flaking tool; 6, unidentifiable pieces; 7, beveled pebble hammerstone; 8-17, projectile points of Orient Fishtail type, 11, has battered point and edges from use as strike-a-light; 18, lumps of decomposed iron pyrites, altered to limonite; 19, brown flint core fragments; 20, grooved bannerstone.

Provenience: 1-9, found over the feature proper; 10-20, found in close association with the stone pots shown in plate 29.

Materials: all white quartz except 9, 17, shale; 20, slate, or as noted above.

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PLATE 31

Artifacts from Feature 2, Jamesport site (21-23, 26, 27, 28, 30, 31), from area in vicinity of this feature (11-20), and from disturbed fill of previous excavation overlying this portion of the pit (1-10).

1, corded potsherd; 2, strike-a-light; 3-7, 9, 11-19, Orient Fishtail points; 8, broad stemmed point; 10, narrow stemmed point or drill; 20, claystone concretion; 21-24, 28, 29, 31, stone vessel sherds (29 is heavily encrusted with red ocher); 25, portion of large stone blade; 26, calcined bone fragments; 27, side-notched point; 30, gorget.

Materials: 2-5, 8-11, 14-16, 18, 19, quartz; 7, gray flint; 6, 12, 13, 17, quartzite; 21-24, 28, 29, 31, amphibole-talc; 25, 27, compact shale; 30, banded slate, or as mentioned above.

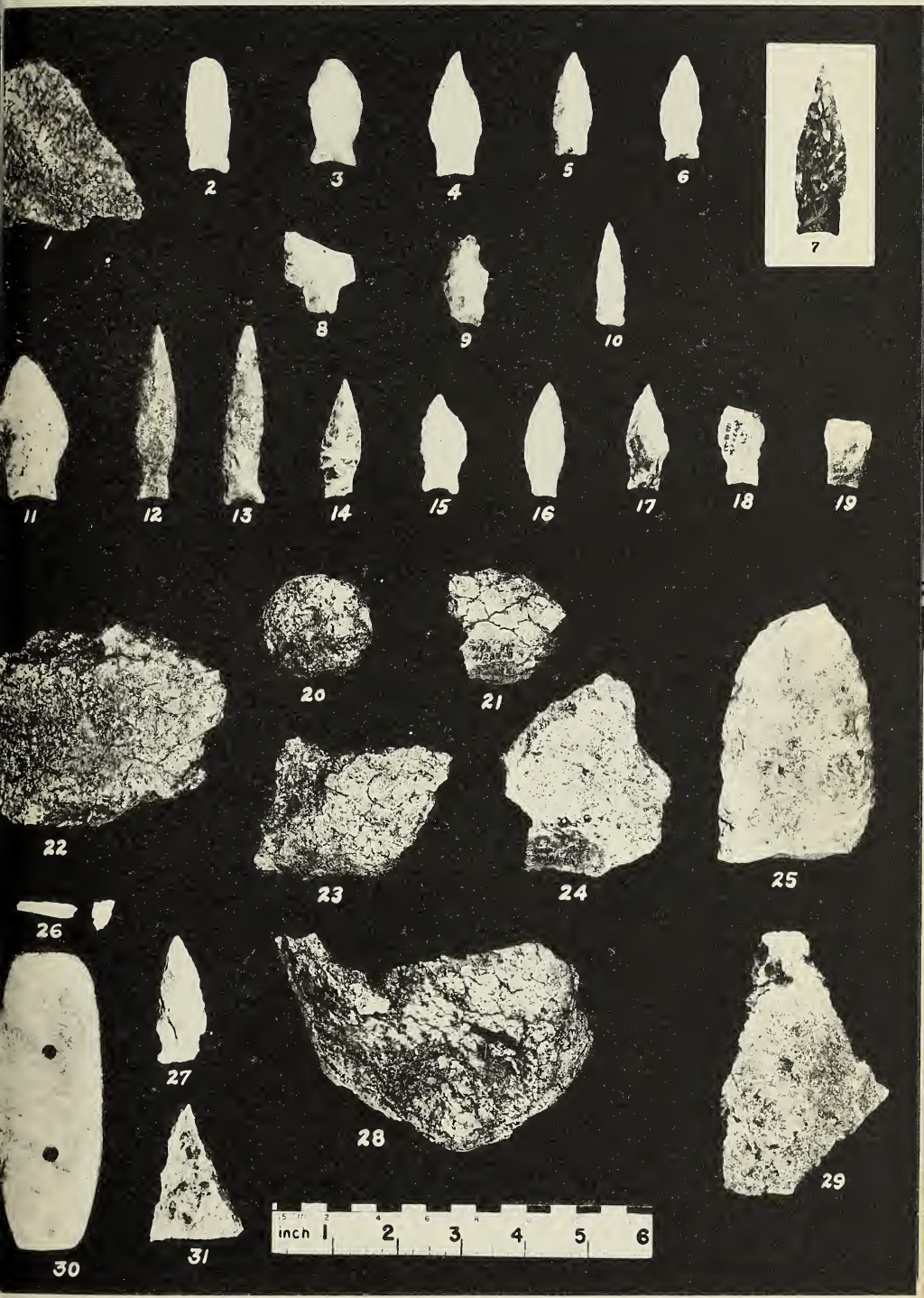
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PLATE 32

Artifacts found in western portion of Jamesport mortuary pit. 1-7, from shallow levels of prior disturbance; 8-27, from deep levels showing little or no disturbance. 1-3, 5-13, 17-21, Orient Fishtail points; 4, narrow side-notched point; 14, strike-a-light; 15, 16, 23-27, stone potsherds; 22, beveled pebble hammerstone.

Materials: 1, 3, 8-14, 17-22, quartz; 2, 4, compact shale; 5-7, tan jasper; 15, 16, 23-27, amphibole-talc.

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PLATE 33

Artifacts found in disturbed area of eastern portion of Jamesport mortuary pit. 1-8, 13-15, 17, Orient Fishtail points; 9, smooth potsherd; 10, 11, corded potsherds; 12, 16, narrow stemmed points; 18-20, side-notched points; 21-23, stone potsherds; 24, stone ornament (?).

Materials: 1, 2, 4-7, 12, quartz; 3, quartzite; 8, 18, felsite; 13, tan jasper; 14, indurated sandy shale; 15-17, 19, 20, indurated shale; 21-24, amphibole-talc.

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PLATE 34

Pottery from Jamesport and Sugar Loaf Hill sites. Found by excavations of the Long Island Chapter, New York State Archeological Association, 1937 and 1941. 1, 3, portions of an oval vessel from Sugar Loaf Hill; 2, portion of a similar vessel from the Jamesport site.

Specimens loaned through courtesy of Roy Latham.

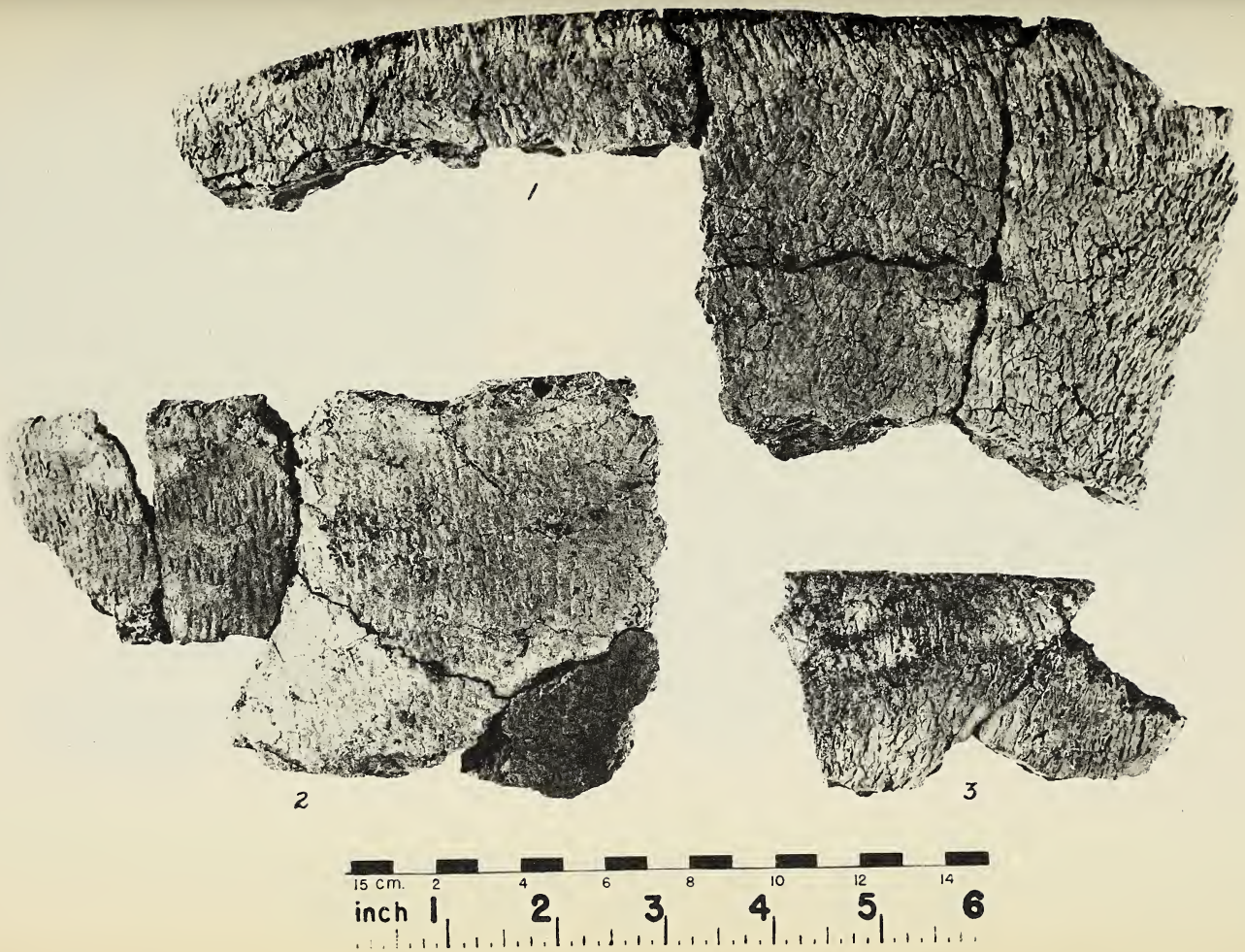
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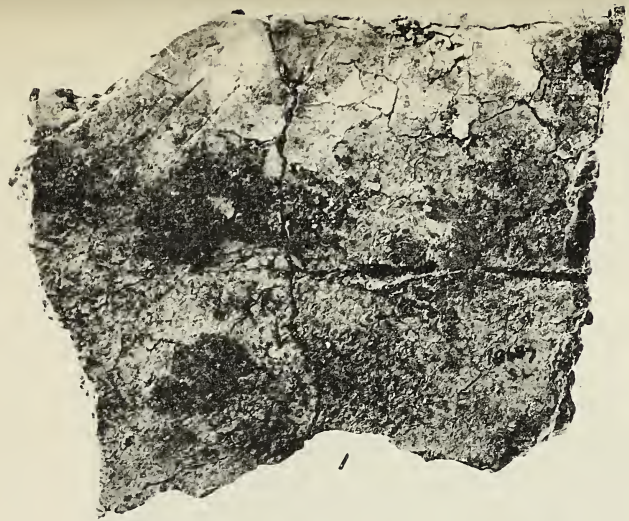
PLATE 35
Interior surface of pottery illustrated on Plate 34. 1-3, Sugar Loaf Hill; 4, Jamesport site.



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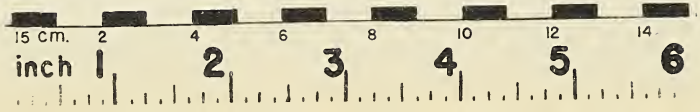


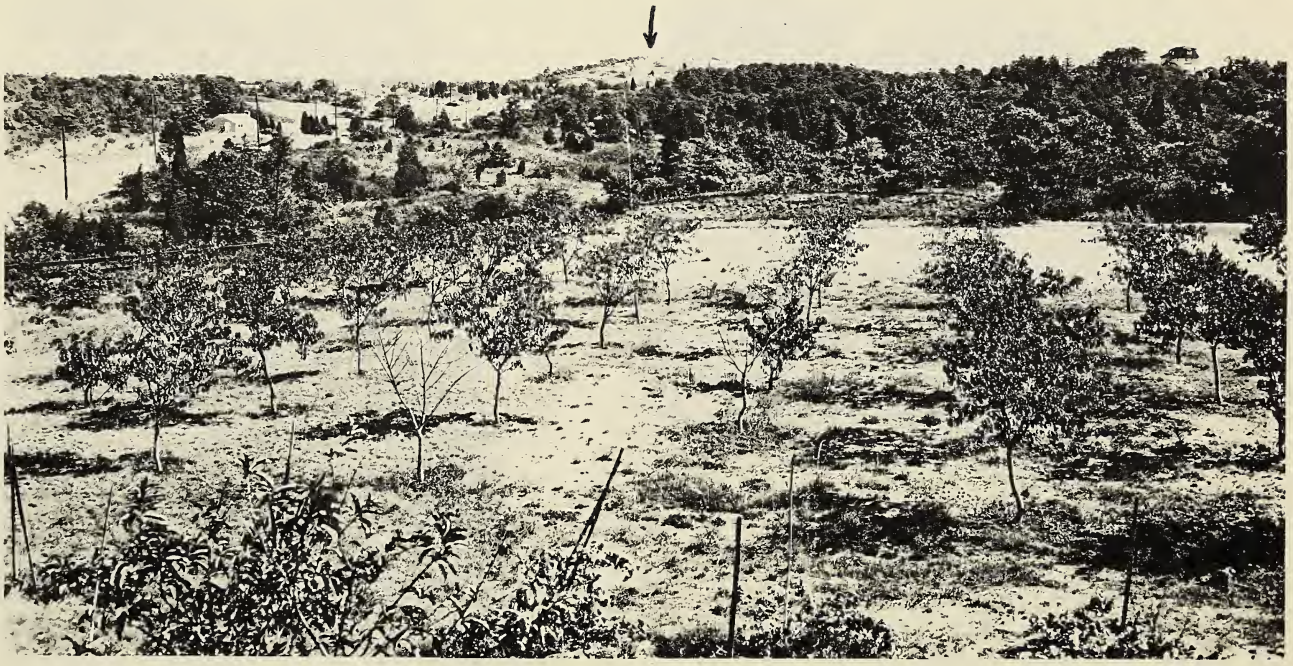


PLATE 36
View of Sugar Loaf Hill, looking nearly east. Montauk highway (route 27) may be seen at left.

PLATE 37

View southwest across Shinnecock Bay from summit of Sugar Loaf Hill. Arrow points to water tower referred to in Figure 6.

PLATE 38
Looking northwest from top of Sugar Loaf Hill toward Great Peconic Bay

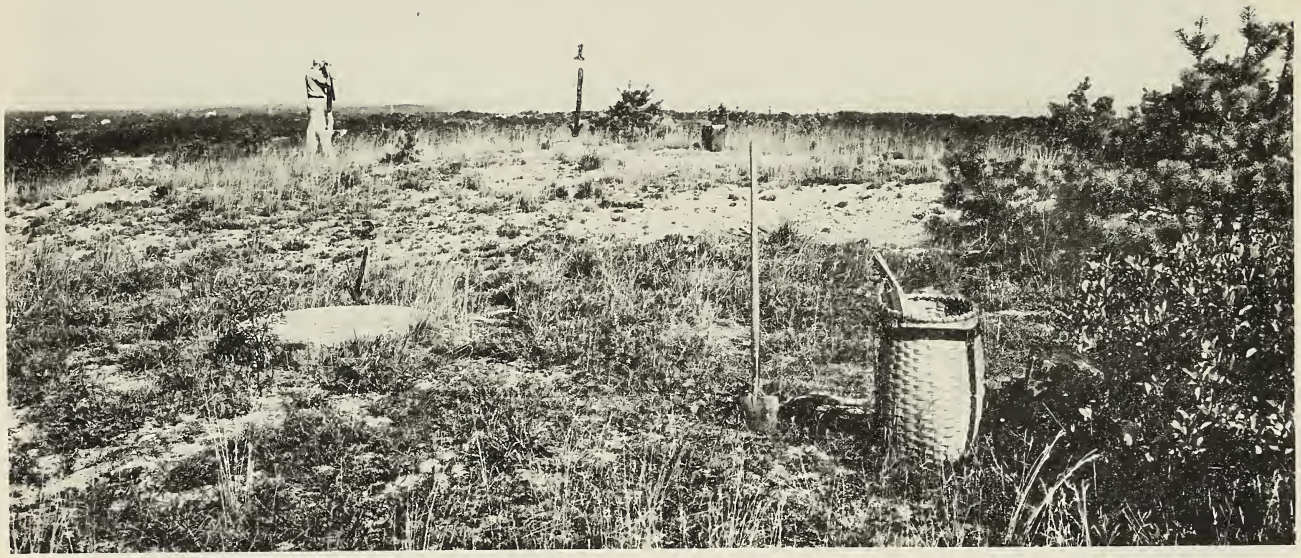


PLATE 39

Summit area of Sugar Loaf Hill, looking northwest, prior to excavations of 1956. Central triangulation monument and closest cistern cap shown in Figure 1, indicated by arrows 1 and 2, respectively.

PLATE 40

Concentration No. 1 of burial goods in northwest end of Feature 1, Sugar Loaf Hill site. For nature of objects indicated by arrows, see page 71 of text. Note charcoal sample in cigar box, obtained from vicinity of maximum concentration of artifacts at arrow 1.

PLATE 41

Section across Feature 1, Sugar Loaf Hill site, near southeast end. Concentration No. 2 of burial goods coming to light (at arrow). Note curving dark band of charred material crossing section just over artifacts

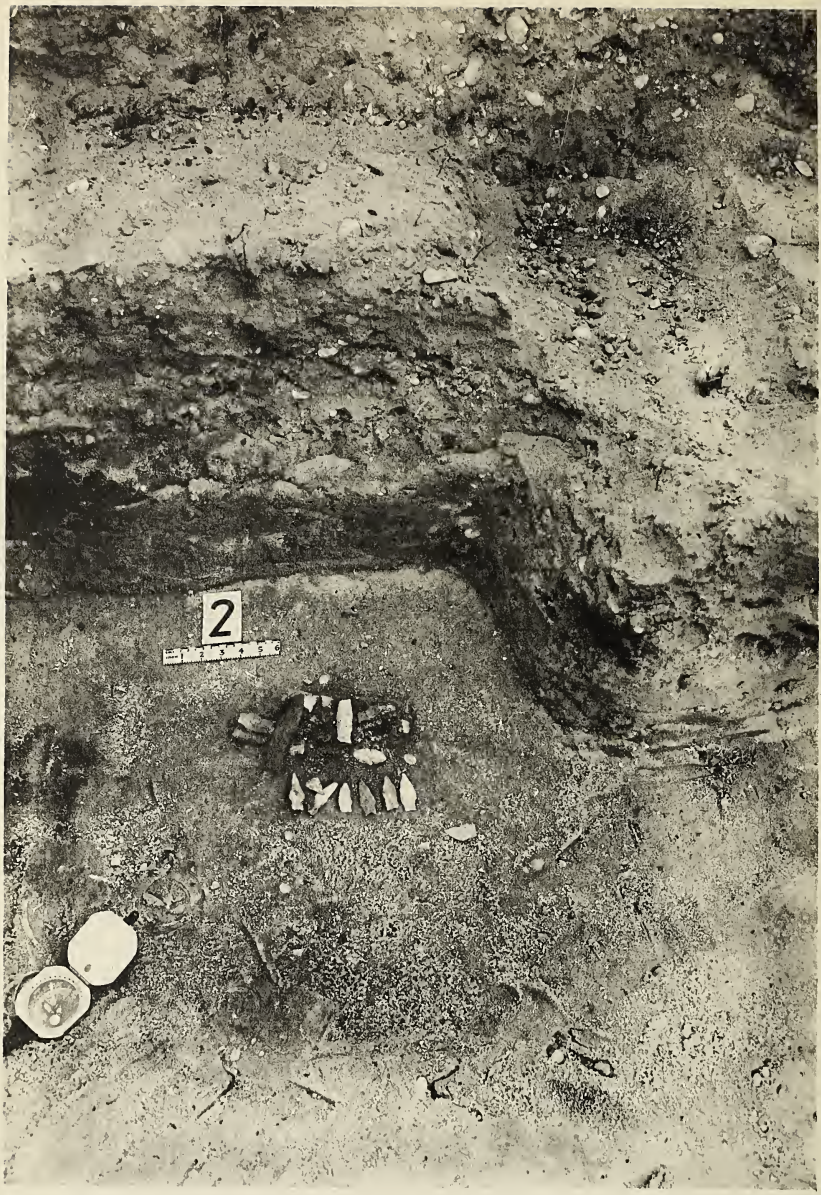


PLATE 42
Artifact concentration No. 2 fully exposed in Feature 1, Sugar Loaf Hill site. Note: points in line nearest camera not in original positions.

PLATE 43

Fragments of intentionally broken stone pot from concentration No. 1, Feature 1, Sugar Loaf Hill site.

Material: amphibole-talc.

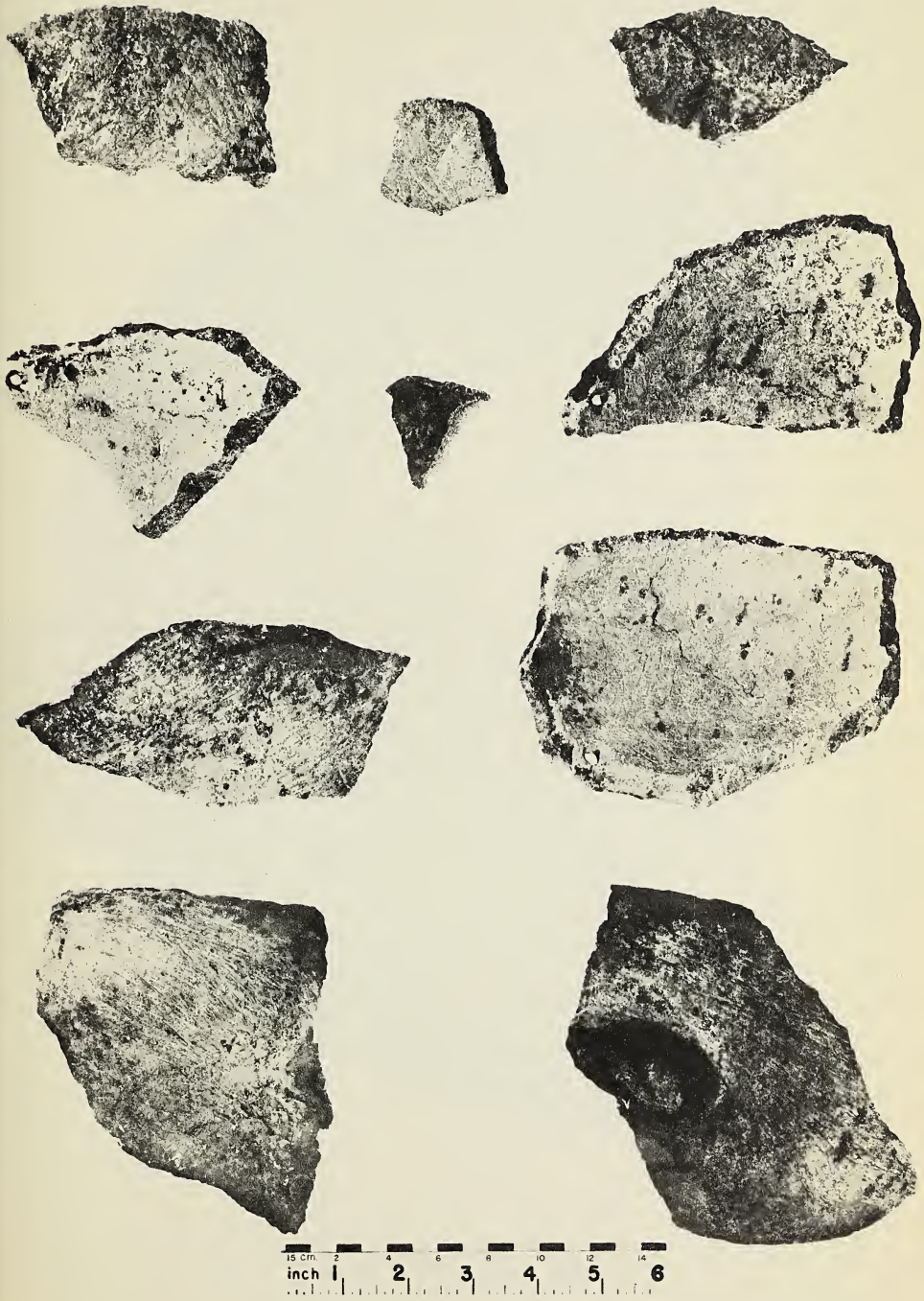

15 cm 2 4 6 8 10 12 14
inch 1 2 3 4 5 6

PLATE 44

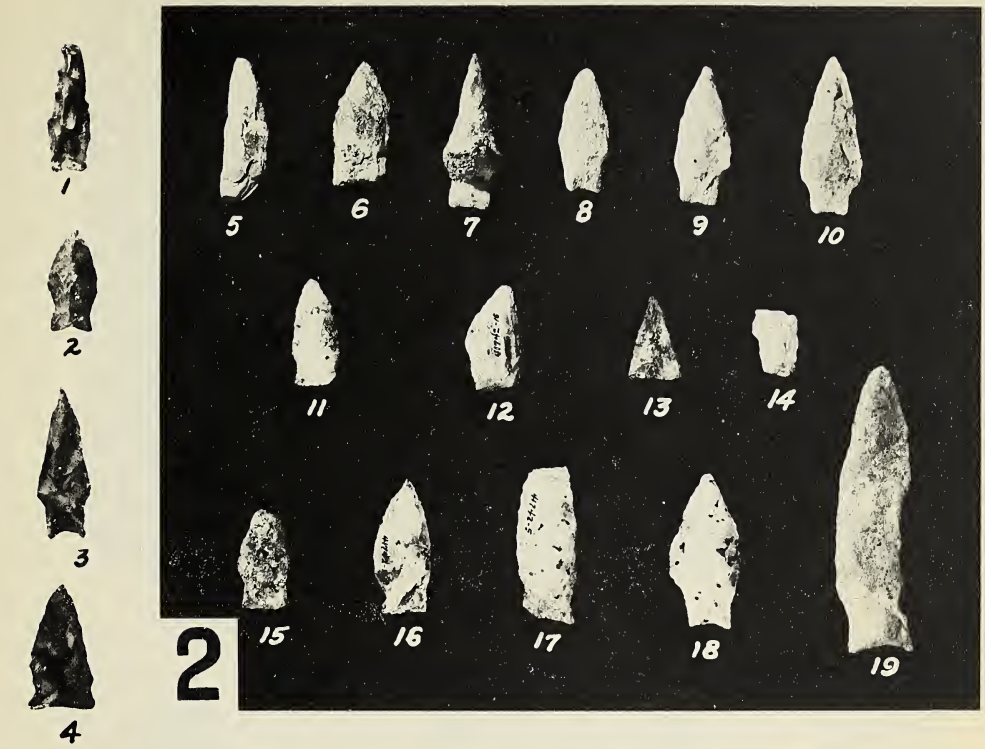
Reassembled stone pot fragments shown in plate 43. Arrows point to lacing holes.

15 cm. 2 4 6 8 10 12 14
inch 1 2 3 4 5 6

PLATE 45

Artifacts from concentration No. 1 (20-33), and concentration No. 2 (1-19) of burial goods in Feature 1, Sugar Loaf Hill site. 1, 7, 21, 22, 32, drills; 2, 3, 6, 8-11, 16-20, 23, Orient Fishtail points; 4, eared side-notched point; 5, 12, 13, 24, 25, fragmentary projectile points of indeterminate form; 14, 27, chips of siltstone and quartz, respectively; 15, strike-a-light; 26, split quartz pebble; 28, 29, beveled pebble hammerstones; 30, narrow stemmed point; 31, faceted hematite paintstone; 33, adze.

Materials: 1-4, 7, 13, 32, dark gray flint; 5, 8-10, 14, 19, siltstone; 6, felsite; 11, 12, 15-18, 20-23, 25-29, quartz; 24, 30, quartzite; 33, dolerite. Note heavy adhesions of limonite (decomposed iron pyrite) on Nos. 6, 7, 11-13, 15.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15 cm
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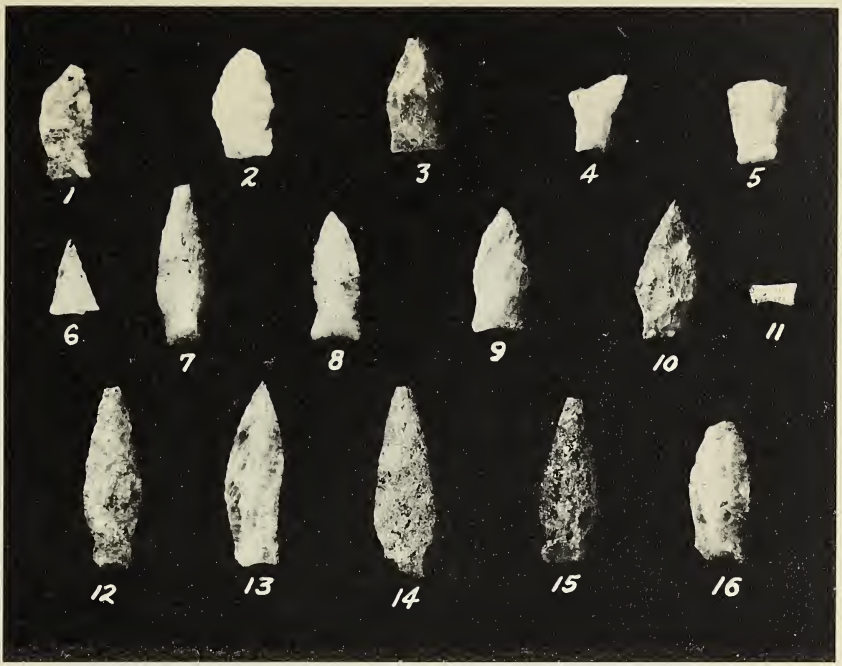
PLATE 46

Artifacts found in disturbed fill of prior excavations (1-16, 18-25) and on site surface (17), at Sugar Loaf Hill site. 1, 3-5, 7-10, 12-16, Orient Fishtail points; 2, narrow stemmed point; 6, 11, 18, fragments of projectile points; 17, triangular point with bifurcated base; 19, narrow side-notched point; 20, chipped hammerstone; 21, 22, 24, stone pot fragments; 23, 25, corded potsherds.

Materials: 1-9, 11-16, quartz; 10, quartzite; 17, 19, flint; 18, felsite; 20, compact shale; 21, 22, 24, amphibole-talc.



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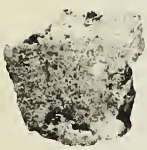
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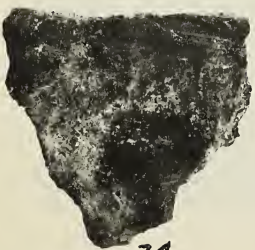
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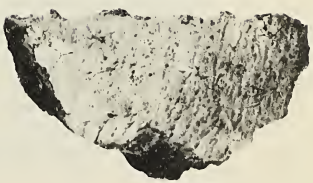
25

PLATE 47
Looking east across Wading River and marsh, from highland bordering Wading River site on the north

PLATE 48
Locus of Wading River site in hollow lying to right in plate 47, looking southeast

PLATE 49
Wading River site prior to excavation, looking east

PLATE 50

Southwest corner of Section N0E0, showing stratigraphy. Stake N0E0 is nearly behind rod. Wading River site.

PLATE 51

Artifacts from Wading River site. 1, 3, 6, equilateral triangular points; 2, 4, 5, isosceles triangular points; 7, rim and neck sherds of dentate stamped pottery; 8-11, 13-16, 19-24, 27, 28, narrow, stemmed points; 12, narrow, side-notched point; 17, broad, stemmed point; 18, broad, corner-notched point; 25, 26, broad, side-notched points; 29, 30, lobate stemmed points; 31, celt; 32, 35, paintstones; 33, notched chopper; 34, 36, bannerstones (36, a fragment, shows secondary use as an anvilstone).

Materials: 1-4, 8-24, 26-30, quartz; 5, felsite; 6, flint; 25, 31, 33, quartzite; 32, 35, hematitic arkose; 34, 36, arkosic sandstone.

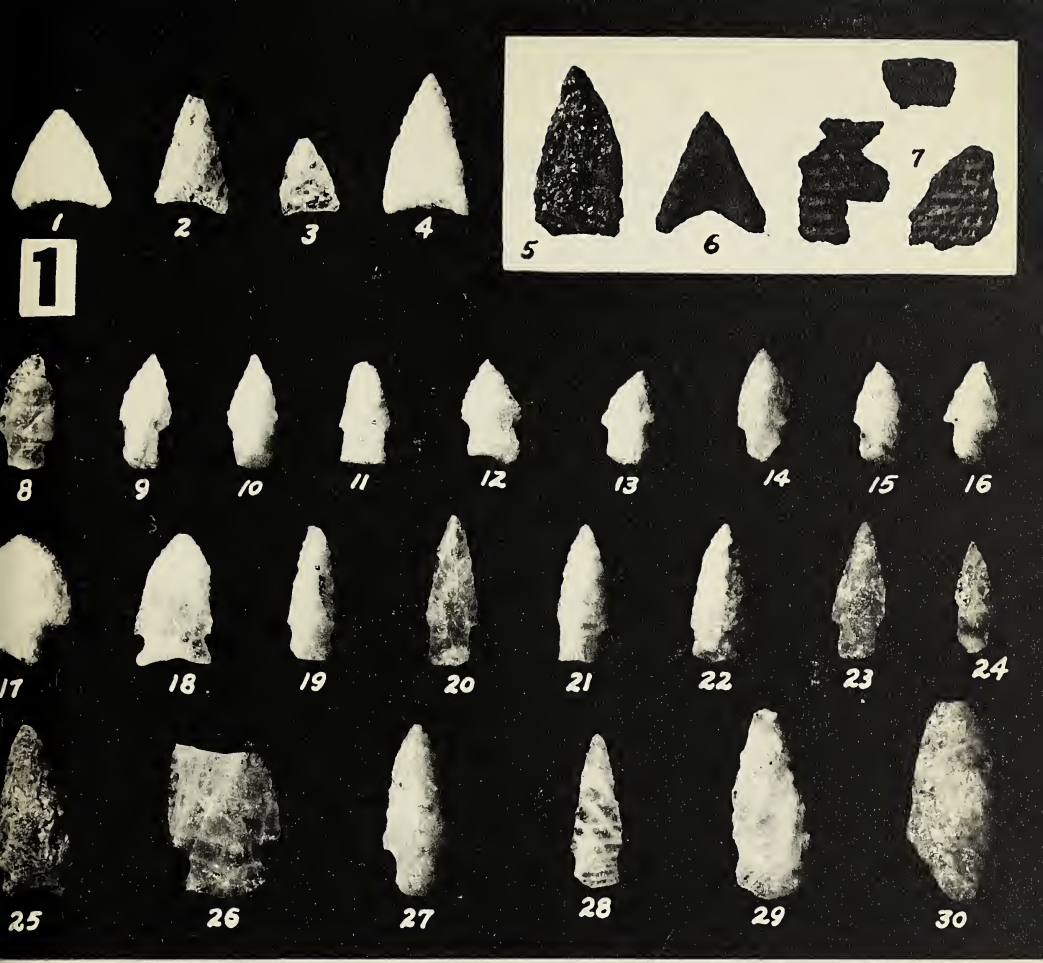
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PLATE 52

Artifacts from Arrowhead Beach site, Fishers Island, N. Y. 1, broad, stemmed point; 2, broad, side-notched point; 3-5, isosceles triangular points; 6-24, narrow, stemmed points; 25, fully grooved axe.

Materials: 1-7, 12-14, 18, 21, 22, quartzite, all others quartz, except 25, of greenstone.

From collection of Henry L. Ferguson. Photographed by courtesy of Mr. Ferguson.

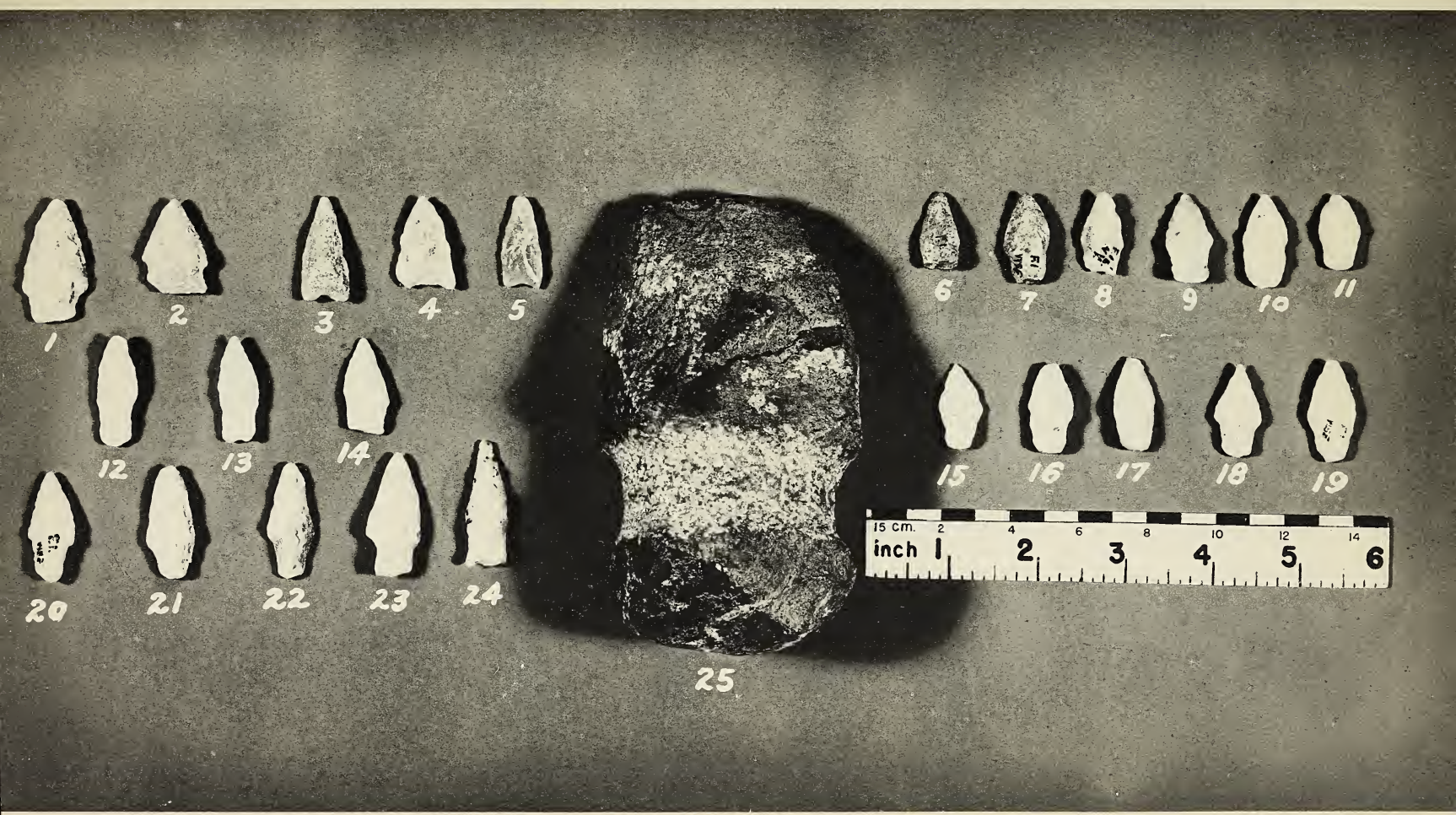
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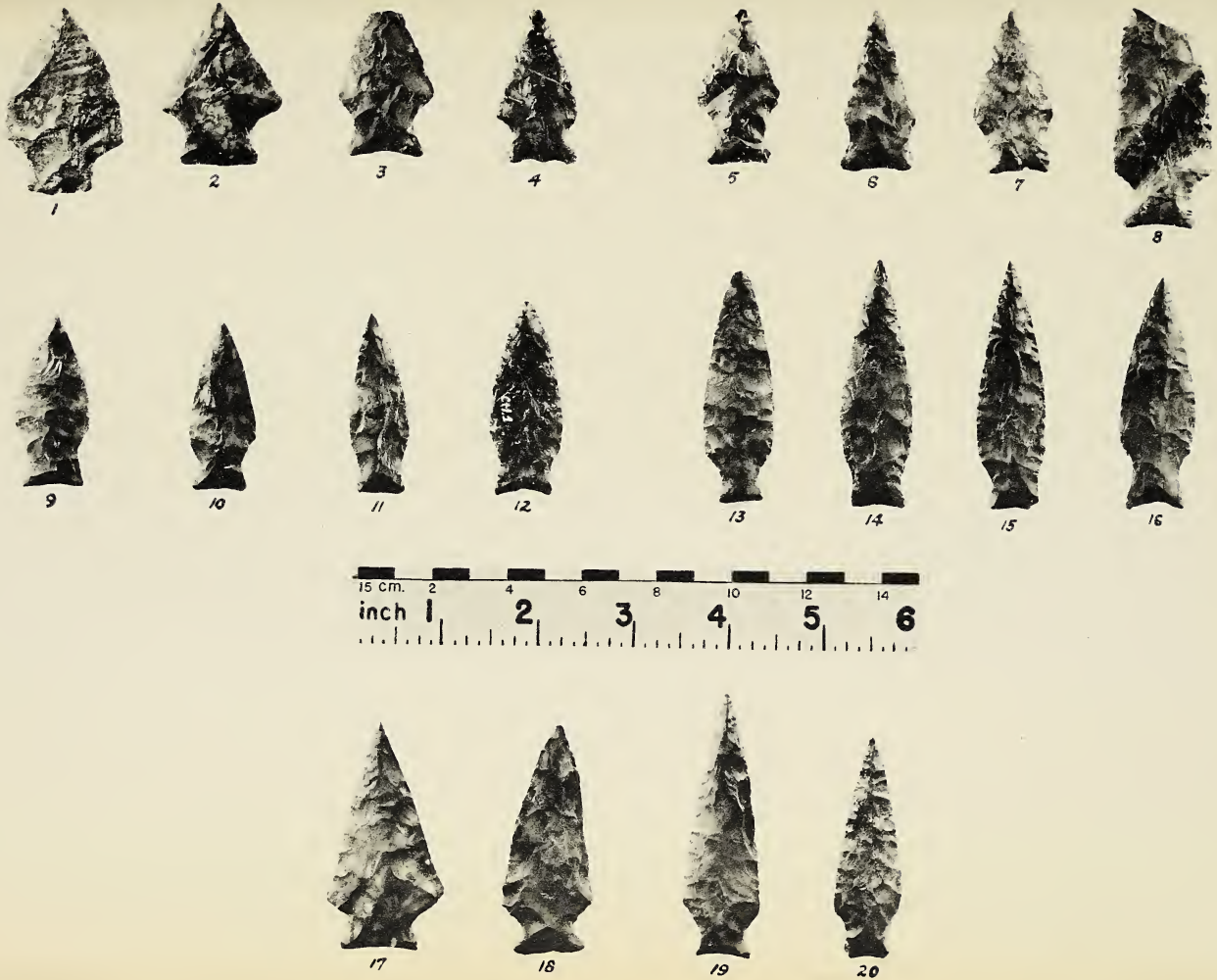
PLATE 53

Projectile points of Susquehanna Broad (1-4, 17), intermediate (5-8, 18, 19) and Orient Fishtail (9-16, 20) forms.

1-16, surface finds on Van Orden site, Greene County, N. Y., by Carl S. Sundler, West Albany, N. Y.; 17-20, surface finds along Seneca River in central New York.

Materials: 1, rhyolite; all others, local flints.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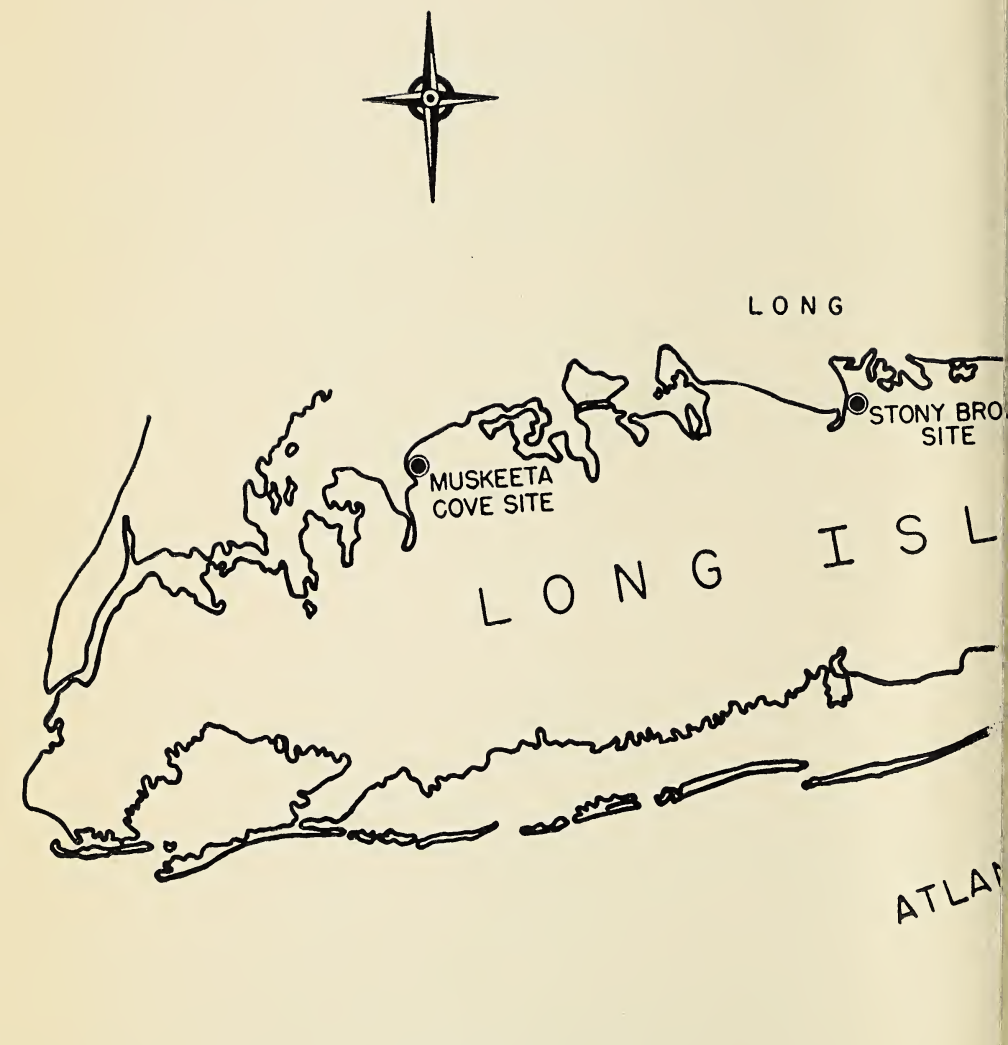
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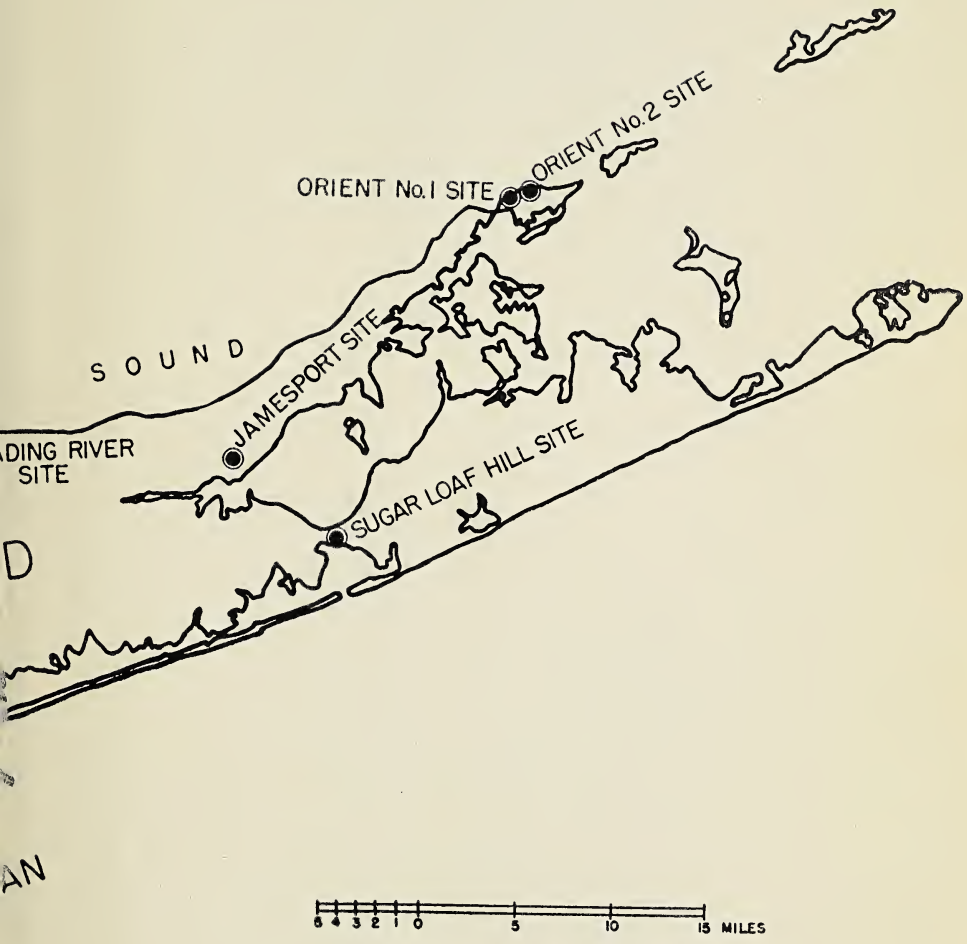
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ADING RIVER
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SUGAR LOAF HILL SITE
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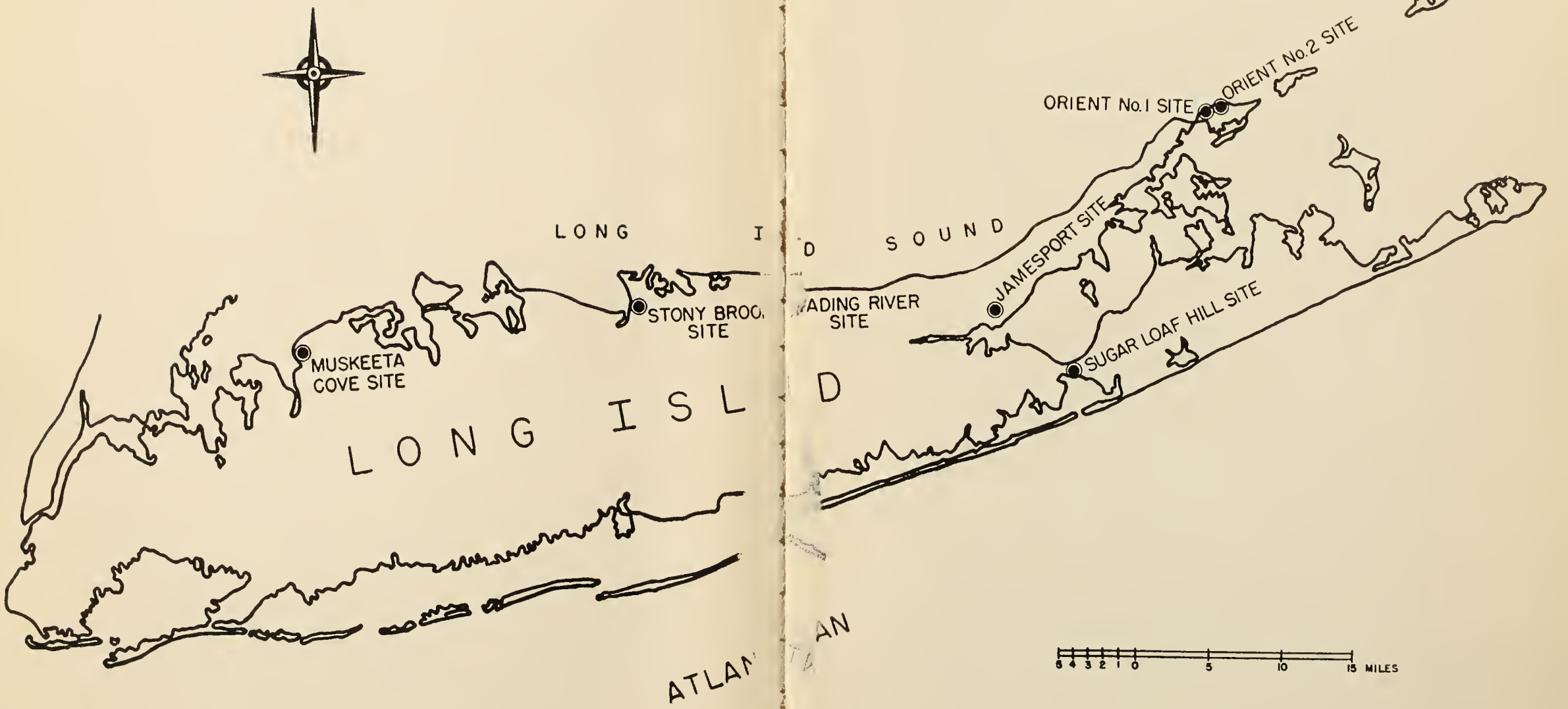
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ORIENT No.2 SITE
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ADING RIVER SITE
STONY BROO SITE
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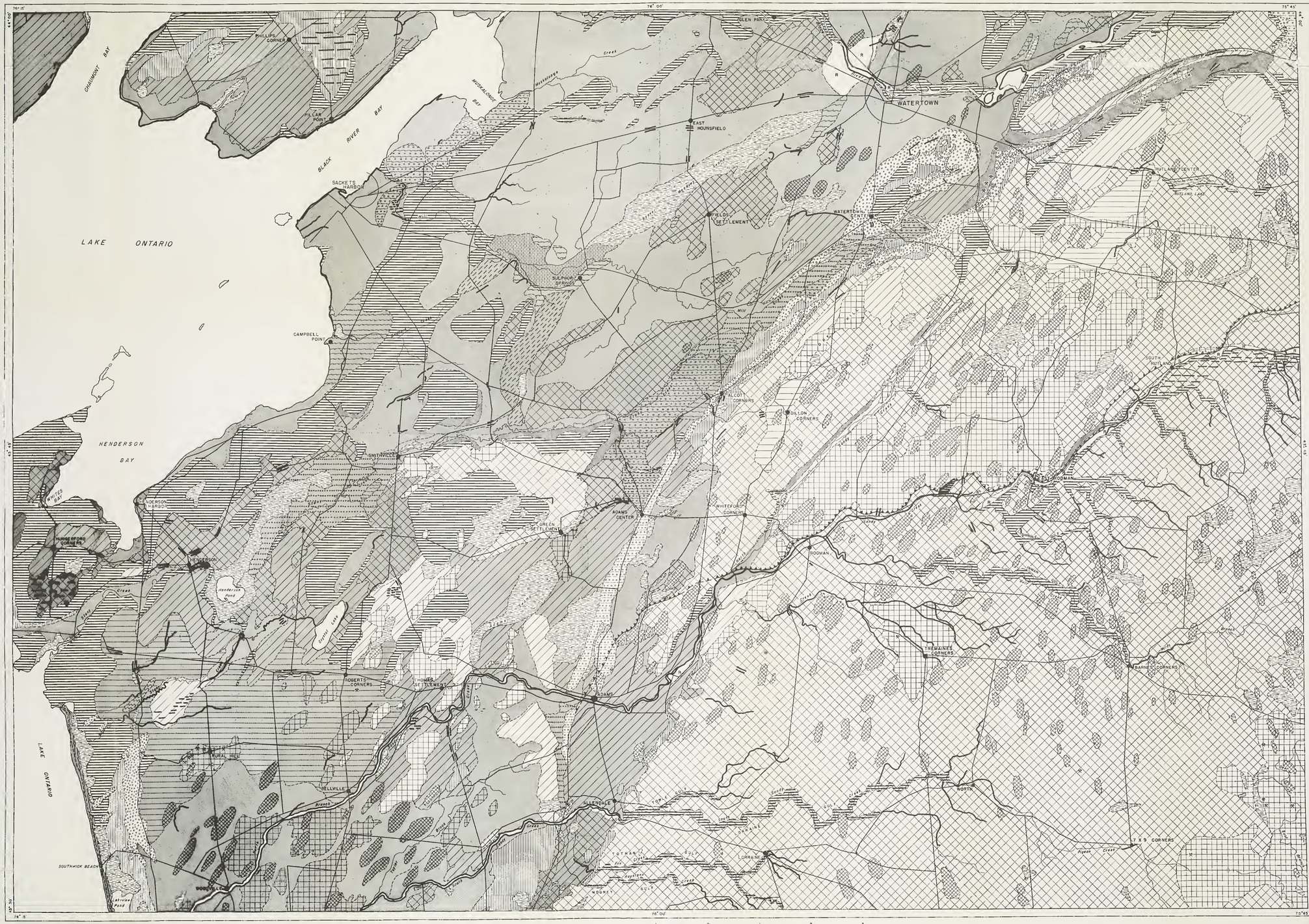

LEGEND

- MORAINIC TOPOGRAPHY---composed of till, topography undulating to rough
- GROUND MORAINE---composed of till, topography level to undulating
- DRUMLINS
- KAMIC MORAINE---composed of gravel, topography undulating to rolling
- KAME TERRACES---ice contact gravel terraces
- OUTWASH PLAIN---composed of sorted gravel, topography generally level
- WASHED OFF TILL---till from which finer materials have been removed by wave action, bouldery surface
- BEACH GRAVEL---gravel deposited along lake shore
- BEACH RIDGE
- OFFSHORE BARS
- LAKE SEDIMENTS---composed predominantly of silt and clay
- LAKE SEDIMENTS---composed of a high percent of sand
- LAKE SEDIMENTS---composed of sands with eolian sands and dunes on the surface
- LAKE SEDIMENTS OVER MORAINE
- LAKE SEDIMENTS OVER GROUND MORAINE
- LAKE SEDIMENTS OVER DRUMLINS
- LAKE SEDIMENTS OVER KAMIC MORAINE
- LAKE SEDIMENTS OVER OUTWASH
- SWAMP & POOR DRAINAGE CONDITIONS ---peat and muck
- EOLIAN SANDS & DUNES
- BEDROCK
- BEDROCK EXPOSURES
- ALLUVIAL SILTS---stream deposits composed predominantly of silt with varying amounts of clay
- ALLUVIAL SANDS---stream deposits composed predominantly of sand
- CONTACT BETWEEN OLDER & YOUNGER DRIFTS---maximum advance of the younger.
- RECENT (POST GLACIAL) ALLUVIAL MATERIAL---unclassified silts, sands, and gravels — R

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GEOLOGY OF THE WATERTOWN AND SACKETS HARBOR QUADRANGLES

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